AIRPLANE RADIO SETS

TYPES SCR-133, 134, 135

AND INTERPHONE SETS, SCR-155, 160, AND
RECEIVING EQUIPMENT USED IN
CONJUNCTION THEREWITH

Radio Communication Pamphlet No. 42

PREPARED IN THE OFFICE OF
THE CHIEF SIGNAL OFFICER

March, 1925

WASHINGTON
GOVERNMENT PRINTING OFFICE
1925

TABLE OF CONTENTS

	Page
Transmitting equipment SCR–133	1
Parts list SCR–133	9
Transmitting equipment SCR–134	10
Parts list SCR–134	18
Parts list SCR–160	18
Transmitting equipment SCR–135	19
Transmitting equipment SCR–155	19
Parts list SCR–135	31
Parts list SCR–155	31
Receiving equipment SCR's 133, 134, 135	32
Receiving equipment without transmitter	36

ILLUSTRATIONS

	Figure
Circuit diagram BD–46	1
Circuit diagram BC–129	2
Circuit diagram SCR–133, transmitter	3
Circuit diagram BC–130	4
Set box BC–129, front view	5
Set box BC–129, rear inside view	6
Set box BC–129, top inside view	7
Control box, BC–130, outside front view	8
Control box, BC–130, inside view	9
Cording diagram SCR–133	10
Dynamotor BD–46	11
Dynamotor BD–46 (cover removed from base)	12
Circuit diagram BC–114	14
Circuit diagram BD–41	15
Cording diagram SCR–160	16
Cording diagram SCR–134	17
Circuit diagram BC–119	18
Schematic diagram BC–114	19
Calibration scale BC–119	20
Control box BC–119, front view	21
Control box BC–119, inside view	22
Dynamotor unit BD–41	23
Radio transmitter BC–114, front view	24
Radio transmitter BC–114, inside view	25
Cording diagram, SCR–135 and SCR–155	26
Circuit diagram BC–121	27

	Figure
Circuit diagram BC–120	28
Circuit diagram BC–110	29
Circuit diagram BC–123	30
Circuit diagram BD–43	31
Circuit diagram BC–126	32
Radio control box BC–121, front view	33
Radio control box BC–121, inside view	34
Schematic circuit diagram BC–110, for telephone operation	35
Schematic circuit diagram BC–110, for telegraph operation	36
Radio transmitter BC–110, rear inside view	37
Radio transmitter BC–110, front view	38
Radio control box BC–120, front view	39
Radio control box BC–120, inside view	40
Dynamotor BD–43	41
Interfone control box BC–123, inside view	42
Radio box parts BC–126, inside and outside view	43
Interfone control box BC–123, front view	44
Cording diagram SCR–160	45
Circuit diagram BC–115	46
Circuit diagram BC–116	47
Amplifier BC–116, front view	48
Amplifier BC–116, rear inside view	49
Tuner BC–115, rear inside view	50
Box, battery, BC–128	51
Tuner BC–115, front view showing tube	52
Tuner BC–115, bottom view	53
Tuner BC–115, front view outside	54

NOTICE

The parts list contained in this pamphlet are not to be used as a basis for requisitioning equipment. Signal Corps Catalogue, Volume I, "Organization Equipment of the Signal Corps," will be used as a basis for all requisitions.

TRANSMITTING EQUIPMENT FOR SCR–133—AIRPLANE RADIO TELEPHONE SET

1. Purpose of set.—The SCR–133 set is intended for communication between pursuit planes in flight formation up to a distance of 5 miles. The set is designed for telephone communication only. The wave frequency range is 850 to 1,500 kilocycles (200 to 350 meters). The set includes a superheterodyne type of receiver to be installed in the plane for the purpose of receiving signals from other planes or ground stations. The wave frequency range of the receiver is 250 to 1,500 kilocycles.

GENERAL DESCRIPTION OF TRANSMITTING EQUIPMENT

2. Parts.—A dynamotor unit, type BD–46, is connected to the 12-volt storage battery provided for operation of the radio set. The 350-volt power developed by the dynamotor operates the plate circuit of radio transmitter BC–129, the filament circuit being supplied from the 12-volt line. The radio transmitter contains all of the radio circuits except the antenna tuning inductance and ammeter which are located in the radio control box BC–130. The control box is the only part of the transmitting equipment which is installed in the airplane cockpit and therefore is accessible to the operator during flight. All multi-conductor cables are connected by means of specially designed plugs, as indicated on Figure 10.

3. Dynamotor unit BD–46.—Dynamotor, type DM–1, includes a motor operating from 12 volts and a generator developing 350 volts under load. The motor and generator armature windings are on the same shaft. The relay is mounted under the dynamotor for controlling the 12-volt supply to the dynamotor and the radio transmitter filament circuit. A four-point plug and socket provide for connection of four-conductor cord connecting to the radio transmitter. Views of the dynamotor unit are shown on Figure 11 and Figure 12. The dynamotor unit measures 7½ inches high, 9¾ inches long, including plug, and 6¼ inches wide, and weighs 18 pounds.

4. Radio transmitter, type BC–129.—The radio apparatus in radio transmitter BC–129 is mounted either on the bakelite panel or supported by a metal frame attached to the back of the panel. The panel is removed from the wood box by turning the handles of the

panel locks upwards, to a horizontal position, pulling the panel forward by means of the handles of the panel locks, and then lifting the panel off the pivots attached to the wood box. The tube shelf is attached rigidly to the supports as the rubber shock absorber cord used to suspend the radio transmitter provides sufficiently against vibration and jars. Three VT–2 tubes are placed in the sockets mounted on the tube shelf. Sockets are mounted on the panel to receive the plugs of cords connecting to other parts of the radio set. The radio transmitter measures 14 inches wide including eyes, 10¼ inches high and 7⅞ inches deep, including plugs, and weighs 13¼ pounds with plugs.

5. Views of the radio transmitter are shown on Figure 5, Figure 6, and Figure 7. The apparatus legend is the same as used in the circuit diagrams shown later in this pamphlet.

APPARATUS LEGEND

A =Milliammeter, range O–200 M. A.
C =Condenser, 1,000 m. m. f.
C_1 =Condenser, 615 m. m. f.
C_2 =Condenser, 500 m. m. f.
C_3 =Condenser, 370 m. m. f.
C_4 =Condenser, 4,000 m. m. f.
C_5 =Condenser, 250 m. m. f.
L =Radio-frequency choke coil.
R =Resistance, 2.7 ohms.
R_1 =Resistance, 5,000 ohms.
R_2 =Resistance, 5,200 ohms.
R_3 =Resistance, 500 ohms.
R_4 =Resistance, 25 ohms.
V =Variometer.
T =Modulation transformer, type C–60.
T_1 =Microphone transformer, type C–51–A.
T_2 =Output transformer.

6. **Radio Control Box, type BC–130.**—The antenna tuning circuit is contained in the radio-control box, which is mounted within reach of the operator. On the panel are mounted an antenna current thermoammeter, the transmit-receive switch, and variometer adjustment knob. The control box measures 6⅛ inches wide, 8½ inches high, including plugs, and 5½ inches deep, including knob on front, and weighs 4 pounds, including plugs.

7. Views of the control box are shown on Figure 8 and Figure 9.

8. **Installing the set.**—Detailed instructions for the installation of the set in various types of planes, including description of the trailing wire antenna to be used, will be issued from time to time by the Air Service. The sets are intended for use in single-seater pursuit planes which will have magneto ignition. No difficulty is experienced in shielding the ignition system so as to prevent excessive interference with the radio receiver in the plane. Specially shielded cables are therefore not required for connecting the various parts of the radio set. The cording diagram for the SCR–133 set is shown on Figure 10. The various types of multiconductor cable required in wiring the SCR–133 set according to Figure 10 are called for in the parts list. The conductors are to be carefully soldered to copper terminals, Belden code Nabob. The end of the terminals is to be firmly pressed around the rubber insulation so that no bending can occur where the bare conductor is soldered to the terminal. If the terminals are found to work loose under the fastening screw of the plug contact stud, the terminals may be sweated to the plug contact studs or small lock washers provided. The various conductors must be carefully indentified at the two ends of the cable, using a buzzer, headset, or other convenient means, in order that a conductor may connect to the same numbered plug contact stud at each end. The single conductor wire W–65 is to be provided with the Delco terminals No. 20953. The end of the terminals is to be formed around the rubber insulation and then securely bound to the insulation by means of heavy thread, afterwards varnished to prevent slipping.

9. **Operation and care of set.**—The only parts of the radio set which are accessible to the operator during flight are the radio control box and the receiving tuner. All power to the radio set is cut off when the transmit-receive switch is on "Off." Throwing the switch to "Transmit" causes the relay on the dynamotor unit to close, starting up the dynamotor and lighting the transmitting tube filaments. When the switch is thrown to "Receive" the receiving tubes are lighted. As the BC–129 radio transmitter is not accessible to the operator during flight, all adjustments must be made before leaving the ground. The pointer on the shaft of the master oscillator variometer should be turned to the wave frequency desired and the setting fixed by means of the locking device. Before leaving the ground, the radio set should be tested by connecting a dummy antenna consisting of a capacity of 250 m. m. f. and a noninductive resistance of 4 ohms between the "Antenna" binding post on the under side of the control box and the ground connection to the plane. The transmit-receive switch should be thrown to "Transmit." Then, the antenna variometer adjustment can be turned slowly until maximum reading of the antenna current ammeter is obtained. When a loud note is sung into the microphone the antenna current should increase slightly, indicating that the set is modulating properly. The milliammeter A indicates the total plate current. The total plate current should be about 0.120 ampere when operating at 800 kilocycles

and 0.160 ampere when operating at 1,600 kilocycles. The normal antenna current is 0.8 ampere. The test thus made determines whether the radio transmitting equipment is operating properly. The antenna tuning adjustment used is not suitable when using the airplane trailing wire antenna, and therefore the antenna circuit must be carefully tuned again when the airplane is in the air.

10. When the airplane has attained sufficient altitude, the trailing wire antenna is let out by means of the antenna reel. With the airplane flying a straight course at normal speed, the transmit-receive switch should be thrown to " Transmit," which will start the BC–129 radio transmitter operating. Then, carefully adjust the antenna variometer until maximum reading of the antenna current ammeter is obtained. The operator throws the transmit-receive switch to " Receive " to connect the antenna to the receiving equipment and light the receiver tubes.

PRINCIPLES EMBODIED IN THE SET AND THE CIRCUIT DIAGRAMS

11. Dynamotor unit, type BD–46.—Circuit diagram of the dynamotor unit is shown on Figure 1. The motor of the dynamotor and the filament circuit of the radio set are supplied from the 12-volt storage battery. The motor is started by the closing of the relay mounted on the panel above the dynamotor. The relay contacts also close the filament current supply circuit. The relay winding is controlled by the transmit-receive switch in the radio-control box. The field winding of the motor also supplies the excitation for the high-voltage generator. A 2 mf. condenser is connected across the high voltage armature for the purpose of smoothing out variations in output due to commutation, and to protect the armature from high voltage surges obtained due to modulation of the radio transmitter. The high voltage generator supplies the plate current for all the tubes.

12. Radio transmitter, type BC–129.—Circuit diagram of the radio transmitter is shown on Figure 2. A complete schematic diagram of the transmitting equipment is shown on Figure 3. The apparatus legend is the same as used for the other diagrams and photographs in this pamphlet.

SCHEMATIC DIAGRAM—SCR–133 TRANSMITTING EQUIPMENT

APPARATUS LEGEND (FIG. 5)

A =Milliammeter, range 0–200 M. A.
A_1 =Hot wire ammeter, 0–1.5A, on BC–130.
C =Condenser, 1,000 m. m. f.
C_1 =Condenser, 615 m. m. f.
C_2 =Condenser, 500 m. m. f.

C_3 =Condenser, 370 m. m. f.
C_4 =Condenser, 4,000 m. m. f.
C_5 =Condenser, 250 m. m. f.
L =Radio frequency choke coil.
R =Resistance, 2.7 ohms.
R_1 =Resistance, 5,000 ohms.
R_2 =Resistance, 5,200 ohms.
R_3 =Resistance, 500 ohms.
R_4 =Resistance, 25 ohms.
S =Send-receive switch, on BC 130.
S_1 =Relay switch, on BD 46.
V =Variometer, master oscillator.
V_1 =Variometer, on BC–130.
T =Modulation transformer, type C–60.
T_1 =Microphone transformer, type C–51–A.
T_2 =Output transformer.

13. Master oscillator.—The master oscillator-power amplifier circuit is used. The master oscillator is a Colpitt's type circuit formed by condensers C_1 and C_3, and variometer inductance V. The condenser C is a blocking condenser to keep the direct plate current from the tube grid. The radio-frequency choke coil L prevents the short-circuit of the radio-frequency voltage through the plate voltage-generator to the filament. The large grid leak-resistances R_1 and R_2 operate with the grid-condenser C to provide a negative grid-biasing voltage by accumulative rectification of the radio-frequency energy since the grid takes current during only the positive half of the cycle. The resistance R_2 is tapped so that the negative potential built up across the 3,400-ohms portion may be used for negative biasing the grid of the modulator tube.

14. The power-amplifier tube has the grid circuit excited by the radio-frequency voltage supplied by connecting across the plate circuit of the master oscillator. The radio-frequency voltage is amplified by the power-amplifier tube so that the plate current has a large radio-frequency component. This radio-frequency energy is transferred to the antenna circuit by means of the antenna or output transformer T_2. The primary (plate) winding consists of a large inductance so designed as to offer large reactance to the radio-frequency current over the wave-frequency band covered by the radio transmitter. This prevents the power amplifier obtaining excessive plate current, when the antenna circuit is detuned. The secondary (antenna) winding consists of a small number of turns, so that the small radio-frequency current and large voltage operating through the tube plate to filament impedance is stepped down to a large radio-frequency current and small voltage which is more suitable for supplying current to the low-resistance antenna. The antenna circuit is tuned to resonance by means of the variometer V_1 in the

radio-control box in order to obtain maximum antenna current as indicated by radio-frequency ammeter A_1 on the radio-control box.

15. The resistance R_3 in the grid circuit of the power-amplifier tube is for the purpose of reducing the grid current flowing in the power-amplifier tube during the positive half-cycle. Otherwise this grid current is particularly large during the interval due to the plate-audio modulation when the effective plate-voltage is low. This varying load on the master-oscillator circuit changes the wave frequency slightly which is objectionable. The condenser C_2 blocks the direct plate-voltage on the master oscillator from reaching the power-amplifier grid. The grid of the power-amplifier tube is kept at a negative-bias potential by means of the accumulative rectification in the grid circuit of the radio-frequency excitation provided by the master oscillator. Condenser C_2 acts as the grid condenser and the two resistances R_1 act as the grid leak in this case. The power-amplifier grid-leak circuit includes a radio-frequency choke L which reduces the radio-frequency current passing through the two resistances R_1. The plate current for the power-amplifier tube is supplied through the 1:1 ratio-modulation transformer, T. The condenser C_4 provides a low-reactance by-pass so that the radio-frequency component of plate current need not pass through the modulation transformer.

16. Modulation.—Power is obtained for the microphone circuit by connecting across the 12-volt supply. The resistance B_4 fixes the direct current through the microphone at the proper value. The microphone T–11 is equipped with an open circuiting switch mounted on the stem. Sound waves striking the microphone diaphragm cause an audio (voice) frequency alternating current to be set up in the circuit. This alternating-current voltage is impressed on the primary of the high-ratio transformer T_1 and is stepped up by the transformer and then impressed on the grid of the modulator tube. A steady negative biasing potential is supplied the voice amplifier tube grid by utilizing part of the voltage developed across the resistance R_2 as explained previously.

17. Modulation of radio-frequency output.—The audio-frequency voltage on the modulator grid is repeated in the plate circuit in amplified form. This plate circuit is supplied from the 350-volt dynamotor armature, the plate current passing through one winding of transformer T. This is a 1:1 ratio transformer. The two windings are connected in opposition so that the magnetic flux set up by one winding approximately neutralizes the flux set up by the other winding. This design prevents magnetic saturation of the core enabling a smaller size and lighter weight core to be used. When the audio frequency component of plate current to the modulator tube increases, the transformer T has a voltage induced in the power amplifier plate winding so that the plate current to this tube also increases. The audio-frequency modulation therefore causes the power amplifier and modulator plate currents to increase and decrease together, following the wave form of the original modulation. The radio transmitter is so designed that the radio-frequency output of the power amplifier is directly proportional to its effective plate voltage (or current). The audio variations in the plate current cause corresponding variations in the radio-frequency output affecting the desired audio-frequency modulation of the radio-frequency wave. The modulator plate circuit includes a radio-frequency choke coil, L, which tends to eliminate any radio-frequency current which may be set up in the circuit due to induction.

18. Side tone circuit.—The quality and presence of modulation in the modulator plate circuit is assured the operator by hearing his own signal by means of the side-tone circuit provided. This connects the modulator plate through the telephone head set plugged into the radio control box, completing the circuit through the 60-volt receiver plate battery to the receiver ground connection. The side-tone circuit contains the condenser C_5 in order to block any direct-current flow, and also to moderate the volume of side tone so as to be suitable for the headset.

19. The filament circuits of all the tubes are supplied in parallel from the 12-volt line. Individual resistances, R, fix the filament current at the proper value for VT–2 tubes. The voltage supplied to the set is about 11 volts, 1 volt approximately being required for the potential drop in the power-supply leads.

20. Radio control box, BC–130.—Circuit diagram of the radio control box is shown on Figure 4. The transmit-receive switch connects the antenna either to the radio transmitter or receiver. The antenna transmitting circuit in the control box includes a variometer V_1, permitting fine adjustment of tuning. The antenna current thermo-ammeter A_1 is connected on the low voltage side of the inductance. The transmit-receive switch S when thrown to transmit closes the dynamotor unit relay winding circuit causing the relay to close, which in turn starts up the dynamotor and closes the transmitter filament circuit. The transmit-receive switch when thrown to receive closes the receiver filament circuit.

21. The SCR–133 transmitting and receiving equipment is calibrated in kilocycles. The conversion table below is a convenient chart for use in converting meters to kilocycles. It will be noted that for frequencies up to 1,500 kilocycles the frequency is given in equally spaced divisions, as the frequency separation is an indication of the amount of interference to be expected between two stations.

CONVERSION TABLE

KILOCYCLES TO METERS

The following conversion table is reversible; that is, for example, 50 kilocycles is 5,996 meters and also 50 meters is 5,996 kilocycles. The range of the table is easily extended by shifting the decimal point; for example, one can not find 223 in the first column, but its equivalent is obtained by finding later in the table that 2,330 kilocycles or meters is equivalent to 134.4 meters or kilocycles, from which 223 kilocycles or meters is equivalent to 1,344 meters or kilocycles.

10	29,980	660	454.3	1,310	228.9	1,960	153.0	2,610	114.9
20	14,990	670	447.5	1,320	227.1	1,970	152.2	2,620	114.4
30	9,994	680	440.9	1,330	225.4	1,980	151.4	2,630	114.0
40	7,496	690	434.5	1,340	223.7	1,990	150.7	2,640	113.6
50	5,996	700	428.3	1,350	222.1	2,000	149.9	2,650	113.1
60	4,997	710	422.3	1,360	220.4	2,010	149.2	2,660	112.7
70	4,283	720	416.4	1,370	218.8	2,020	148.4	2,670	112.3
80	3,748	730	410.7	1,380	217.3	2,030	147.7	2,680	111.9
90	3,331	740	405.2	1,390	215.7	2,040	147.0	2,690	111.5
100	2,998	750	399.8	1,400	214.2	2,050	146.3	2,700	111.0
110	2,726	760	394.5	1,410	212.6	2,060	145.5	2,710	110.6
120	2,499	770	389.4	1,420	211.1	2,070	144.8	2,720	110.2
130	2,306	780	384.4	1,430	209.7	2,080	144.1	2,730	109.8
140	2,142	790	379.5	1,440	208.2	2,090	143.5	2,740	109.4
150	1,999	800	374.8	1,450	206.8	2,100	142.8	2,750	109.0
160	1,874	810	370.2	1,460	205.4	2,110	142.1	2,760	108.6
170	1,764	820	365.6	1,470	204.0	2,120	141.4	2,770	108.2
180	1,666	830	361.2	1,480	202.6	2,130	140.8	2,780	107.8
190	1,578	840	356.9	1,490	201.2	2,140	140.1	2,790	107.5
200	1,499	850	352.7	1,500	199.9	2,150	139.5	2,800	107.1
210	1,428	860	348.6	1,510	198.6	2,160	138.8	2,810	106.7
220	1,363	870	344.6	1,520	197.2	2,170	138.1	2,820	106.3
230	1,304	880	340.7	1,530	196.0	2,180	137.5	2,830	105.9
240	1,249	890	336.9	1,540	194.7	2,190	139.6	2,840	105.6
250	1,199	900	333.1	1,550	193.4	2,200	136.3	2,850	105.2
260	1,153	910	329.5	1,560	192.2	2,210	135.7	2,860	104.8
270	1,110	920	325.9	1,570	191.0	2,220	135.1	2,870	104.5
280	1,071	930	322.4	1,580	189.8	2,230	134.4	2,880	104.1
290	1,034	940	319.0	1,590	188.6	2,240	133.8	2,890	103.7
300	999.4	950	315.6	1,600	187.4	2,250	133.3	2,900	103.4
310	967.2	960	312.3	1,610	186.2	2,260	132.7	2,910	103.0
320	936.9	970	309.1	1,620	185.1	2,270	132.1	2,920	102.7
330	908.6	980	305.9	1,630	183.9	2,280	131.5	2,930	102.3
340	881.8	990	302.8	1,640	182.8	2,290	130.9	2,940	102.0
350	856.6	1,000	299.8	1,650	181.7	2,300	130.4	2,950	101.6
360	832.8	1,010	296.9	1,660	180.6	2,310	129.8	2,960	101.3
370	810.3	1,020	293.9	1,670	179.5	2,320	129.2	2,970	100.9
380	789.0	1,030	291.1	1,680	178.5	2,330	128.7	2,980	100.6
390	768.8	1,040	288.3	1,690	177.4	2,340	128.1	2,990	100.3
400	749.6	1,050	285.5	1,700	176.4	2,350	127.6	3,000	99.94
410	731.3	1,060	282.8	1,710	175.3	2,360	127.0	3,020	99.28
420	713.9	1,070	280.2	1,720	174.3	2,370	126.5	3,040	98.62
430	697.3	1,080	277.6	1,730	173.3	2,380	126.0	3,060	97.98
440	681.4	1,090	275.1	1,740	172.3	2,390	125.4	3,080	97.34
450	666.3	1,100	272.6	1,750	171.3	2,400	124.9	3,100	96.72
460	651.8	1,110	270.1	1,760	170.4	2,410	124.4	3,120	96.10
470	637.9	1,120	267.7	1,770	169.4	2,420	123.9	3,140	95.48
480	624.6	1,130	265.3	1,780	168.4	2,430	123.4	3,160	94.88
490	611.9	1,140	263.0	1,790	167.5	2,440	122.9	3,180	94.28
500	599.6	1,150	260.7	1,800	166.6	2,450	122.4	3,200	93.69
510	587.9	1,160	258.5	1,810	165.6	2,460	121.9	3,220	93.11
520	576.6	1,170	256.3	1,820	164.7	2,470	121.4	3,240	92.54
530	565.7	1,180	254.1	1,830	163.8	2,480	120.9	3,260	91.97
540	555.2	1,190	252.0	1,840	162.9	2,490	120.4	3,280	91.41
550	545.1	1,200	249.9	1,850	162.1	5,500	119.9	3,300	90.86
560	535.4	1,210	247.8	1,860	161.2	2,510	119.5	2,320	90.31
570	526.0	1,220	245.8	1,870	160.3	2,520	119.0	3,340	89.77
580	516.9	1,230	243.8	1,880	159.5	2,530	118.5	3,360	89.23
590	508.2	1,240	241.8	1,890	158.6	2,540	118.0	3,380	88.70
600	499.7	1,250	239.9	1,900	157.8	2,550	117.6	3,400	88.18
610	491.5	1,260	238.0	1,910	157.0	2,560	117.1	3,420	87.67
620	483.6	1,270	236.1	1,920	156.2	2,570	116.7	3,440	87.16
630	475.9	1,280	234.2	1,930	155.3	2,580	116.2	3,460	86.65
640	468.5	1,290	232.4	1,940	154.5	2,590	115.8	3,480	86.16
650	461.3	1,300	230.6	1,950	153.8	2,600	115.3	3,500	85.66

3,520	85.18	4,220	71.05	4,920	60.94	6,550	45.77	8,300	36.12
3,540	84.70	4,240	70.71	4,940	60.69	6,600	45.43	8,350	35.91
3,560	84.22	4,260	70.38	4,960	60.45	6,650	45.00	8,400	35.69
3,580	83.75	4,280	70.05	4,980	60.20	6,700	44.75	8,450	35.48
3,600	83.28	4,300	69.73	5,000	59.96	6,750	44.42	8,500	35.27
3,620	82.82	4,320	69.40	5,050	59.37	6,800	55.09	8,550	35.07
3,640	82.37	4,340	69.08	5,100	58.79	6,850	43.77	8,600	34.86
3,660	81.92	4,360	68.77	5,150	59.22	6,900	43.45	8,650	34.66
3,680	81.47	4,380	68.45	5,200	57.66	6,950	43.14	8,700	34.46
3,700	81.03	4,400	68.14	5,250	57.11	7,000	42.83	8,750	34.27
3,720	80.60	4,420	67.83	5,300	56.75	7,050	42.53	8,800	34.07
3,740	80.17	4,440	67.53	5,350	56.04	7,100	42.23	8,850	33.88
3,760	79.74	4,460	67.22	5,400	55.52	7,150	41.93	8,900	33.69
3,780	79.32	4,480	66.91	5,450	55.01	7,200	41.64	8,950	33.50
3,800	78.90	4,500	66.63	5,500	54.51	7,250	41.35	9,000	33.31
3,820	78.49	4,520	66.33	5,550	54.02	7,300	41.07	9,050	33.13
3,840	78.08	4,540	66.04	5,600	53.54	7,350	40.79	9,100	32.95
3,860	77.67	4,560	65.75	5,650	53.07	7,400	40.52	9,150	32.77
3,880	77.27	4,580	65.46	5,700	52.60	7,450	40.24	9,200	32.59
3,900	76.88	4,600	65.18	5,750	52.14	7,500	39.98	9,250	32.41
3,920	76.49	4,620	64.90	5,800	51.69	7,550	39.71	9,300	32.24
3,940	76.10	4,640	64.62	5,850	51.25	7,600	39.45	9,350	32.07
3,960	75.71	4,660	64.34	5,900	50.82	7,650	39.19	9,400	31.90
3,980	75.33	4,680	64.06	5,950	50.39	7,700	38.94	9,450	31.73
4,000	74.96	4,700	63.79	6,000	49.97	7,750	38.69	9,500	31.56
4,020	74.58	4,720	63.52	6,050	49.56	7,800	38.44	9,550	31.39
4,040	74.21	4,740	63.25	6,100	49.15	7,850	38.19	9,600	31.23
4,060	73.85	4,760	62.99	6,150	48.75	7,900	37.95	9,650	31.07
4,080	73.49	4,780	62.72	6,200	48.36	7,950	37.71	9,700	30.91
4,100	73.13	4,800	62.46	6,250	47.97	8,000	37.48	9,750	30.75
4,120	72.77	4,820	62.20	6,300	47.59	8,050	37.25	9,800	30.59
4,140	72.42	4,840	61.95	6,350	47.22	8,100	37.02	9,850	30.44
4,160	72.07	4,860	61.69	6,400	46.85	8,150	36.79	9,900	30.28
4,180	71.73	4,880	61.44	6,450	46.48	8,200	36.56	9,950	30.13
4,200	71.39	4,900	61.19	6,500	46.13	8,250	36.34	10,000	29.98

22.

Parts list for airplane radiotelephone set, type SCR–133

Quantity	Unit	Article	Manufacture according to—
1	Each	Radio transmitter, type BC–129	Spec. 71–206.
6	Each	Tubes, type VT–2; 3 in use, 3 spare	Spec. 2113–A.
1	Each	Radio control box, type BC–130	Spec. 71–207.
1	Each	Headset, type HS–14 (or HS–12)	Spec. 71–210.
1	Each	Transmitter, type T–11, microphone	Spec. 71–190.
1	Each	Radio receiving tuner, type BC–115	Spec. 71–58–A.
1	Each	Radio-audio frequency amplifier, type BC–116	Spec. 71–57–C.
1	Each	Plug, type PL–11—Western Electric No. 47–B	Sample.
2	Each	Terminals, type TM–50, for PL–11	Do.
16	Each	Tubes, type VT–5; 8 in use, 8 spare	Spec. 71–178.
9	Each	Batteries, type BA–2; 3 in use, 6 spare	Spec. 70–21.
1	Each	Battery box, type BC–128	Spec. 71–199.
[1] 40	Foot	Cord, type CO–100, 2-conductor, No. 18	Spec. 71–158–B.
[1] 40	Foot	Cord, type CO–102, 4-conductor, No. 18	Spec. 71–158–B.
[1] 50	Foot	Wire, type W–65, single conductor	Spec. 71–160.
1	Each	Terminal, type TM–92; positive-lug	Dwg. RL–D–917–A.
1	Each	Terminal, type TM–93; negative-lug	Dwg. RL–D–917–A.
10	Each	Terminal, type TM–94; Delco No. 20953 or approved equivalent.	Sample.
40	Each	Terminal, type TM–95; Belden "Nabob" or approved equivalent.	Do.
2	Piece	Tubing, soft rubber, ⅛ inch inside, ¼ inch outside, 6 inches long, for receiving storage-battery cord.	
2	Each	Sleeves, tinned copper, receiver storage-battery cord (item 5 of drawing).	Dwg. RL–D–5544–A.
1	Each	Dynamotor unit, type BD–46	Spec. 71–205–A.
3	Each	Batteries, type BB–4, 4-volt storage; 1 in use, 2 spare	To be issued from stock.
450	Foot	Wire, No. 22 B. & S. (0.025-inch) soft-drawn bare copper, in six 75-foot lengths, wound on separate spools permanently marked to show size and lengths; 2 in use, 4 spare.	Spec. 57–211.
60	Foot	Wire, type W–5, in four 15-foot lengths; 2 in use, 2 spare	Spec. 3005.
40	Foot	Cord, type RP–11, in 2-foot lengths	Comm. Std.
4	Each	Insulators, type IN–8	Spec. 2004–A.
2	Each	Insulators, type IN–68, deck type, for lead-in	Dwg. RL–D–5192.
1	Roll	Tape, type TL–83, friction	Spec. 569–C.

[1] Cords will be issued in long lengths and cut to exact requirements at time of installation.

NOTE.—The 12-volt storage battery for operating the radio transmitter, and the 2-conductor No. 6 B. & S. twin conductor cable connecting to the dynamotor unit will be provided by the Air Service.

TRANSMITTING EQUIPMENT FOR SCR–134—AIRPLANE RADIO TELEPHONE AND TELEGRAPH SET

1. Purpose of set.—The SCR–134 set is a corps observation plane set intended for long-range artillery fire control, etc. The set is designed for telephone communication with ground sets up to a distance of 30 miles. Tone modulated telegraph and C. W. telegraph can also be used, providing a greater distance range. The wave frequency range is 400 to 850 kilocycles (350 to 750 meters). The set includes a superheterodyne type of receiver to be installed in the plane for the purpose of receiving signals from other planes or ground stations. The wave frequency range of the receiver is 250 to 1,500 kilocycles.

GENERAL DESCRIPTION OF TRANSMITTING EQUIPMENT

2. Parts.—A dynamotor unit, type BD–41, is connected to the 12-volt storage battery forming part of the central power plant of the airplane. The 750-volt power developed by the dynamotor operates the plate circuit of radio transmitter BC–114, the filament circuit being supplied from the 12-volt line. The radio transmitter contains all of the radio circuits except the antenna tuning inductance and ammeter which are located in the radio control box BC–119. The control box is the only part of the transmitting equipment which is installed in the airplane rear cockpit and therefore is accessible to the observer who operates the set. All multiconductor cables are connected by means of specially designed plugs as indicated on Figure 17.

3. Dynamotor unit, BD–41.—Dynamotor type DM–13–B includes a motor operating from 12 volts and a generator developing 750 volts under load. A panel is mounted above the dynamotor carrying a relay for controlling the 12-volt supply to the dynamotor and the radio transmitter filament circuit. A large six-point plug and socket provide for connection of six conductor cord connecting to the radio transmitter. A view of the dynamotor unit is shown on Figure 23. The dynamotor unit measures 11⅛ inches high, not including plug, 9 inches long, and 7¾ inches wide, and weighs 27 pounds.

4. Radio transmitter, BC–114.—The radio apparatus in radio transmitter BC–114 is mounted either on the bakelite panel or supported

by a metal frame attached to the back of the panel. The panel is removed from the wood box by turning the handles of the panel locks upward, pulling the panel forward by means of the handles of the panel locks, and then lifting the panel off the pivots attached to the wood box. The tube shelf is attached rigidly to the supports as the rubber shock-absorber cord used to suspend the radio transmitter provides sufficiently against vibration and jars. Three VT–4 tubes and one VT–2 tube are placed in the sockets mounted on the tube shelf. Sockets are mounted on the panel to receive the plugs of cords connecting to other parts of the radio set. The radio transmitter measures 18 inches wide including eyes, 14⅞ inches high, and 8¾ inches deep, not including plugs, and weighs 25½ pounds without tubes or plugs.

5. Views of the radio transmitter are shown on Figure 24 and Figure 25. The apparatus legend is the same as used in the circuit diagrams shown later in this pamphlet.

APPARATUS LEGEND

A	=D. C. milliammeter, 0 to 500 milliamperes.
C_1	=4,000 m. m. f. condenser.
C_2	=2,500 m. m. f. condenser.
C_3	=1,500 m. m. f. condenser.
C_4	=500 m. m. f. condenser.
C_5	=5,000 m. m. f. condenser.
C_6	=500 m. m. f. condenser.
R_1	=0.36 ohm resistance.
R_2	=2.7 ohm resistance.
R_3	=500 ohm resistance.
R_4	=20,000 ohm resistance.
R_5	=15,000 ohm resistance, tapped at 2,500 ohms.
R_6	=0.5 megohm resistance.
R_7	=5,000 ohm resistance.
R_8	=10,000 ohm resistance.
T_1	=Modulation transformer, type C–55.
T_2	=Voice-amplifying transformer, type C–50.
T_3	=Microphone transformer, type C–51.
T_4	=Antenna transformer.
L_1	=Oscillating variometer.
L_2	=Choke coil, type C–58.
M	=Motor alternator, type GN–33.
S	=Field rheostat.
S_1	=Modulation control switch.

6. Radio control box, BC–119.—The antenna tuning circuit is contained in the radio control box which is mounted within reach of the observer. On the panel are mounted an antenna current thermoammeter, the inductance tap switch and variometer adjustment knob. The transmit-receive switch is mounted conveniently for the use of the operator. The control box measures 6¼ inches wide, 7¼ inches

high, including switch handle, and 6⅜ inches deep, including knobs on front, and weights 5 pounds, not including plugs.

7. Views of the control box are shown on Figure 21 and Figure 22.

8. Installing the set.—Detailed instructions for the installation of the set in various types of planes, including description of trailing wire antenna to be used, will be issued from time to time by the Air Service. The cording diagram of the SCR–134 radio set is shown on Figure 17. When the SCR–160 interphone equipment is to be used in connection with the radio set, cords CD–98 and CD–99 are plugged into the jacks of the BC–119 control box in place of the head set and microphone plugs. The complete cording of the SCR–160 is shown on Figure 45. The use of the adapters enables either new or old type microphones and headsets to be used, depending upon which is available. The material listed in the interphone equipment parts list is the additional equipment required if the interphone is to be used. The various types of multi-conductor cable required in wiring the SCR–134 set according to Figure 17 are called for in the parts list. The conductors are to be carefully soldered to copper terminals, Belden code Nabob. The end of the terminals is to be firmly pressed around the rubber insulation so that no bending can occur where the bared conductor is soldered to the terminal. If the terminals are found to work loose under the fastening screw of the plug contact stud, the terminals may be sweated to the plug contact studs or small lock washers provided. The various conductors must be carefully identified at the two ends of the cable, using a buzzer, head set, or other convenient means, in order that a conductor may connect to the same numbered plug contact stud at each end. The single conductor wire W–65 is to be provided with the Delco terminals No. 20953. The end of the terminals is to be formed around the rubber insulation and then securely bound to the insulation by means of heavy thread, afterwards varnished to prevent slipping.

9. Operation and care of set.—The only parts of the radio set which are accessible to the operator during flight are the radio control box and the receiving tuner. All power to the radio set is cut off when the transmit-receive switch is on "Off." Throwing the switch to "Transmit" causes the relay on the dynamotor unit to close, starting up the dynamotor and lighting the transmitting tube filaments. When the switch is thrown to "Receive" the receiving tubes are lighted. As the BC–114 radio transmitter is not accessible to the operator during flight, all adjustments must be made before leaving the ground. The pointer on the shaft of the master oscillator variometer should be turned to the wave frequency desired and the setting fixed by means of the locking device. The switch on the transmitter panel should be turned to C. W. telegraph, tone telegraph.

or telephone, as desired. If tone telegraph is to be used, the switch marked "Tone control" should be turned to the desired tone. Tone "E" has the highest pitch. Before leaving the ground the radio set should be tested by connecting a dummy antenna consisting of a capacity of 250 m. m. f. and a noninductive resistance of 4 ohms between the "Antenna" binding post on the under side of the control box and the ground connection to the plane. The transmit-receive switch should be thrown to "Transmit" and the inductance switch on the control box turned to the proper wave frequency range. Then, if using telephone, the antenna variometer adjustment can be turned slowly until maximum reading of the antenna current ammeter is obtained. When a loud note is sung into the microphone the antenna current should increase slightly, indicating that the set is modulating properly. If tone telegraph or C. W. telegraph is used, it is necessary to hold down the key during the tuning of the antenna circuit. With the set properly tuned and the key held down, the antenna current should increase slightly when the switch on the radio transmitter is turned from C. W. telegraph to tone telegraph, indicating that proper modulation is obtained. The test thus made determines whether the radio transmitting equipment is operating properly. The antenna tuning adjustment used is not suitable when using the airplane trailing wire antenna, and therefore the antenna circuit must be carefully tuned again when the airplane is in the air.

10. When the airplane has attained sufficient altitude, the trailing wire antenna is let out by means of the antenna reel. With the airplane flying a straight course at normal speed, the transmit-receive switch should be thrown to "Transmit" which will start the BC–114 radio transmitter operating. Then, if using telephone, turn the inductance switch on the control box to the proper wave frequency range and carefully adjust the antenna variometer until maximum reading of the antenna current ammeter is obtained. If tone or C. W. telegraph is being used, it is necessary to hold closed the telegraph sending key during this tuning process. The operator throws the transmit-receive switch to "Receive" to connect the antenna to the receiving equipment and light the receiver tubes.

PRINCIPLES EMBODIED IN THE SET AND THE CIRCUIT DIAGRAMS

11. Dynamotor unit BD–41.—Circuit diagram of the dynamotor unit is shown on Figure 15. The motor of the dyamotor and the filament circuit of the radio set are supplied from the 12-volt storage battery forming part of the central power plant on the airplane. The motor is started by the closing of the relay mounted on the panel above

the dynamotor. The relay contacts also close the filament current supply circuit. The relay winding is controlled by the transmit-receive switch in the radio control box. The field winding of the motor also supplies the excitation for the high-voltage generator. A 2 m. f. condenser is connected across the high-voltage armature for the purpose of smoothing out variations in output due to commutation, and to protect the armature from high-voltage surges obtained due to modulation of the radio transmitter. The high-voltage generator supplies the plate current for all the tubes.

12. Radio Transmitter BC–114.—Circuit diagram of the radio transmitter is shown on Figure 14. A complete schematic diagram of the transmitting equipment is shown on Figure 19. The apparatus legend is the same as used for the other diagrams and photographs in this pamphlet.

SCHEMATIC DIAGRAM—SCR–134 TRANSMITTING EQUIPMENT

APPARATUS LEGEND

A =D. C. milliammeter, 0 to 500 milliamperes.
C_1 =4,000 m. m. f. condenser.
C_2 =2,500 m. m. f. condenser.
C_3 =1,500 m. m. f. condenser.
C_4 =500 m. m. f. condenser.
C_5 =5,000 m. m. f. condenser.
C_6 =500 m. m. f. condenser.
R_1 =0.36 ohm resistance.
R_2 =2.7 ohm resistance.
R_3 =500 ohm resistance.
R_4 =20,000 ohm resistance.
R_5 =15,000 ohm resistance, tapped at 2,500 ohms.
R_6 =0.5 megohm resistance.
R_7 =5,000 ohm resistance.
R_8 =10,000 ohm resistance.
T_1 =Modulation transformer, type C–55.
T_2 =Voice amplifying transformer, type C–50.
T_3 =Microphone transformer, type C–51.
T_4 =Antenna transformer.
L_1 =Oscillating variometer.
L_2 =Choke coil, type C–58.
M =Motor alternator, type GN–33.
S =Field rheostat.
S_1 =Modulation control switch on radio transmitter.
S_2 =Transmit-receive switch on radio control box.
S_3 =Magnetic switch on dynamotor unit.

NOTE.—When using C. W. telegraph, only part of circuit to left of dash line is operating. When using telephone, telegraph sending key is short circuited by S_1.

13. Master oscillator.—The master oscillator-power amplifier circuit is used. The master oscillator is a Colpitt's type circuit formed by condensers C_1, C_2, C_3, and variometer inductance L_1. The condenser C_4 is a blocking condenser to keep the direct plate current from the

tube grid. The radio-frequency choke coil L_2 prevents the short circuit of the radio-frequency voltage through the plate voltage generator to the filament. The large grid leak resistance R_4 operates with the grid condenser C_1 to provide a negative grid biasing voltage by accumulative rectification of the radio-frequency energy since the grid takes current during only the positive half of the cycle. The plate ratio capacity C_2, C_3 is divided in order that the smaller voltage across C_2 may be used for the excitation of the grid circuit of the power-amplifier tube.

14. The power-amplifier tube has the grid circuit excited by the radio-frequency voltage supplied by the master oscillator. The radio-frequency voltage is amplified by the tube so that the plate current has a large radio-frequency component. This radio-frequency energy is transferred to the antenna circuit by means of the antenna or output transformer T_4. The primary (plate) winding consists of a large inductance so designed as to offer large reactance to the radio-frequency current over the wave-frequency band covered by the radio transmitter. This prevents the power amplifier obtaining excessive plate current, when the antenna circuit is detuned. The secondary (antenna) winding consists of a small number of turns, so that the small radio-frequency current and large voltage operating through the tube plate to filament impedance is stepped down to a large radio-frequency current and small voltage which is more suitable for supplying current to the low-resistance antenna. The antenna circuit is tuned to resonance by means of the tapped inductance and variometer in the radio control box in order to obtain maximum antenna current as indicated by radio-frequency ammeter on the radio control box.

15. The resistance R_3 in the grid circuit of the power-amplifier tube is for the purpose of reducing the grid current flowing in the power-amplifier tube during the positive half cycle. Otherwise this grid current is particularly large during the interval due to the plate audio modulation when the effective plate voltage is low. This varying load on the master oscillator circuit changes the wave frequency slightly, which is objectionable. The grid of the power-amplifier tube is kept at a negative bias potential by means of the accumulative rectification in the grid circuit of the radio-frequency excitation provided by the master oscillator. Condenser C_2 acts as the grid condenser and resistance R_5 acts as the grid leak in this case. The resistance R_5 is tapped so that part of the negative potential built up across it may be used for negative biasing the grids of the voice amplifier and modulator tubes. The plate current for the power-amplifier tube is supplied through the modulation transformer T_1. The condenser C_5 provides a low reactance by-pass so

that the radio-frequency component of plate current need not pass through the modulation transformer.

16. **Keying.**—The resistance R_7 is connected between the negative side of the 750-volt generator and the filament circuit, so all plate current drawn passes through this resistance, when connected for telegraph operation with key open. The plate current causes a large negative voltage to be set up across this resistance which is impressed upon all the grid circuits, reducing the total plate current to a very small value. When the key is closed to send a dot or dash, the resistance is short circuited and the plate current quickly reaches normal value. By this means the oscillations reach large amplitude with key closed and drop to zero with key open. This method of keying is used for both C. W. telegraph and tone-modulated telegraph. For telephone operation, the resistance is short circuited by the three-position switch S_1 on the radio-transmitter panel.

17. **Sources of modulation.**—The high-ratio transformer T_3 has an alternating-current voltage impressed on the primary which is stepped up by the transformer and then impressed on the grid of the speech amplifier tube. For tone modulated telegraph the alternating-current voltage is generated by a motor alternator GN–33, the motor of which is connected across the 12-volt circuit. A variable resistance is contained in the motor field circuit in order that the speed may be varied, controlling the frequency generated in the alternating-current windings. By this means various pitch tones can be obtained. This is useful when a number of the sets operating on nearly the same wave frequency are within receiving range. It will be noted that the tone modulation is supplied steadily and that keying is effected by controlling the plate current, the same as for C. W. telegraph. For telephone operation, the motor alternator is replaced as a source of alternating current by a microphone. Power is obtained for the microphone circuit by utilizing the drop across the VT–2 voice amplifier tube. The microphone T–11 is equipped with an open circuiting switch mounted on the stem. The secondary of the step-up transformer T_3 has connected across it a leak type resistance R_6 which serves to improve the modulation and prevent grid blocking, especially if the grid is caused to go positive by excessive modulation. A steady negative biasing potential is supplied the voice amplifier tube grid by utilizing part of the voltage developed across the resistance R_5 as explained previously.

18. The audio-frequency voltage on the voice amplifier grid is repeated in the plate circuit in amplified form. This plate current is supplied from the 750-volt dynamotor armature and is therefore passed through the resistance R_8 in order to reduce the effective voltage to a suitable value for the VT–2 tube. The plate circuit also contains the primary of the one-to-one ratio transformer T_2 which

transfers the audio frequency voltage to the grid circuit of the VT–4 modulator tube. A steady negative biasing potential is supplied the modulator tube grid by utilizing part of the voltage developed across the resistance R_5 as previously explained.

19. **Side tone circuit.**—The quality and presence of modulation so far in the circuit is assured the operator by hearing his own signal by means of the side tone circuit provided. This connects the modulator grid through the telephone head set plugged into the radio control box, completing the circuit through the 60-volt receiver plate battery to the receiver ground connection. The side tone circuit contains the condenser C_6 in order to block any direct-current flow, and also to moderate the volume of side tone so as to be suitable for the head set.

20. **Modulation of radio-frequency output.**—The audio-frequency voltage on the modulator grid is repeated in the plate circuit in amplified form. This plate circuit is supplied from the 750-volt dynamotor armature, the plate current passing through one winding of transformer T_1. This is a special low reluctance core transformer having 1,375 turns between terminals 1 and 2 and 1,750 turns between terminals 3 and 4. The two windings are connected in opposition so that the magnetic flux set up by one winding approximately neutralizes the flux set up by the other winding. This design prevents magnetic saturation of the core enabling a smaller size and lighter weight core to be used. When the audio-frequency component of plate current to the modulator tube increases, the transformer T_1 has a voltage induced in the power amplifier plate winding so that the plate current to this tube also increases. The audio-frequency modulation therefore causes the power amplifier and modulator plate currents to increase and decrease together, following the wave form of the original modulation. The radio transmitter is so designed that the radio-frequency output of the power amplifier is directly proportional to its effective plate voltage (or current). The audio variations in the plate current cause corresponding variations in the radio-frequency output effecting the desired audio-frequency modulation of the radio-frequency wave.

21. The filament circuits of all the tubes are supplied in parallel from the 12-volt line. Individual resistances fix the filament current at the proper values for VT–4 and VT–2 tubes. The voltage supplied to the set is about 11 volts, 1 volt approximately being required for the potential drop in the power supply leads.

22. **Radio control box BC–119.**—Circuit diagram of the radio control box is shown on Fig. 18. The transmit-receive switch connects the antenna either to the radio transmitter or receiver. The antenna transmitting circuit in the control box includes a large tapped inductance with a variometer in series, permitting fine adjustment of

tuning between the taps of the large inductance. The antenna current thermoammeter is connected on the low voltage side of the inductance. The transmit-receive switch when thrown to transmit closes the dynamotor unit relay winding circuit causing the relay to close, which in turn starts up the dynamotor and closes the transmitter filament circuit. The transmit-receive switch when thrown to receive closes the receiver filament circuit.

23.

Parts list for airplane radiotelephone and telegraph set, type SCR–134

Quantity	Unit	Material	Manufacture according to—
1	----------	Radio transmitter, type BC–114	Spec. 71–53–D.
6	----------	Tubes, type VT–4B, 3 in use, 3 spare	Spec. 71–179–E.
2	----------	Tubes, type VT–2; 1 in use, 1 spare	Spec. 2113–A.
1	----------	Radio control box, type BC–119	Spec. 71–55–A.
1	----------	Headset, type HS–14 (or HS–12)	Spec. 71–210.
1	----------	Transmitter, type T–11, microphone	Spec. 71–190.
2	----------	Keys, type J–5	Spec. 3081.
1	----------	Radio receiving tuner, type BC–115	Spec. 71–58–A.
1	----------	Radio-audio frequency amplifier, type BC–116	Spec. 71–57–C.
1	----------	Plug, type PL–11	Mfg. standard.
2	----------	Terminals, type TM–50	Mfg. standard.
16	----------	Tubes, type VT–5; 8 in use, 8 spare	Spec. 71–178.
9	----------	Batteries, type BA–2; 3 in use, 6 spare	Spec. 70–21.
1	----------	Battery box, type BC–128	Spec. 71–199.
[1] 40	Foot	Cord, type CO–100, 2-conductor No. 18	Spec. 71–158–B.
[1] 45	---do---	Cord, type CO–102, 4-conductor No. 18	Spec. 71–158–B.
[1]15	---do---	Cord, type CO–110, 6-conductor No. 18, shielded	Spec. 71–211–A.
[1] 30	---do---	Cord, type CO–111, 2-conductor No. 10, 4 conductor No. 18, shielded.	Spec. 71–212–A.
[1] 60	---do---	Wire, type W–65, single-conductor	Spec. 71–160.
1	----------	Terminal, type TM–92 (positive terminal (lug))	Dwg. RLD–917–A.
1	----------	Terminal, type TM–93 (negative terminal (lug))	Dwg. RLD–917–A.
2	Pieces	Tubing, soft rubber, ⅛ inch by ¼ inch diameters, 6 inches long	Standard.
2	----------	Sleeves, tinned copper, receiver storage battery cord (item 5 of drawing).	Dwg. RLD–5544–A.
7	----------	Terminals, type TM–94 (Delco No. 20953 or app'd equivalent).	
50	----------	Terminals, type TM–95 (Belden "Nabob" or app'd equivalent).	
1	----------	Dynamotor unit, type BD–41	Spec. 71–56–C.
3	----------	Batteries, type BB–4, 4-volt, 1 in use, 2 spare	To be issued from stock.
2	----------	Drums, type DR–2; 1 in use, 1 spare	Dwg. RLC–371.
2	----------	Fairleads, type F–5; 1 in use, 1 spare	Spec. 2068.
1	----------	Reel, type RL–2	Dwg. RLD–369.
20	Foot	Rope, type RP–11	Commercial std.
10	----------	Weights, type WT–1, 1 in use, 9 spare	RL–SK–1012.
3,000	Foot	Wire, type W–5	Spec. 3005.

[1] Cords will be issued in long lengths and cut for exact requirements at time of installation.
NOTE.—The 12–volt storage battery for operating the radio transmitter, and the 2-conductor No. 6 B&S twin conductor cable connecting to the dynamotor unit will be provided by the Air Service.

24.

Parts list for interphone set, type SCR–160

Quantity	Material	Manufacture according to—
1	Set box, type BC–10–C (wiring of BC–10–B changed and box modified in accordance with).	Dwgs. RLC–4235 and RLD–4236.
1	Cord, type CD–6	Spec. 2095.
1	Cord, type CD–98	Spec. 71–201.
1	Cord, type CD–99	Spec. 71–202.
1	Adapter, type FT–70	Spec. 71–203.
1	Adapter, type FT–71	Spec. 71–204.
1	Transmitter, type T–11	Tested as per Spec. 2045.
1	Headset, type HS–14	Spec. 71–210.
20	Batteries, type BA–3; 2 in use, 18 spare	Spec. 70–2–F.

TRANSMITTING EQUIPMENT FOR SCR–135—AIRPLANE RADIO TELEPHONE AND TELEGRAPH SET AND MULTI-STATION INTERPHONE SET, SCR–155

1. Purpose of the set.—The SCR–135 set is a long-range set designed primarily for installation on bombing planes. The set provides telephone communication with ground sets up to a distance of 100 miles. I. C. W. telegraph and C. W. telegraph can also be used, providing a greater distance range. The wave-frequency range is 250 to 350 kilocycles (850 to 1,200 meters). The set includes a superheterodyne type of receiver, to be installed in the plane for the purpose of receiving signals from other planes or ground stations. The wave-frequency range of the receiver is 250 to 1,500 kilocycles.

GENERAL DESCRIPTION OF TRANSMITTING EQUIPMENT

2. Parts.—A dynamotor unit, type BD–43, is connected to the 12-volt storage battery forming part of the central power plant of the airplane. The 800-volt power developed by the dynamotor supplies the plate circuit of radio transmitter BC–110, the filament circuit being supplied from the 12-volt line. The radio transmitter contains all of the radio circuits. The magnetically operated transmit-receive switch is located in the BC–121 control box and is controlled either at this control box or at the BC–120 control box.

3. Dynamotor unit, type BD–43.—Dynamotor, type DM–14, includes a motor operating from 12 volts and a generator developing 800 volts under load. The motor and generator armature windings are on the same shaft. A panel is mounted above the dynamotor carrying a relay for controlling the 12-volt supply to the dynamotor and the radio-transmitter filament circuit. A large 6-point plug and socket provide for connection of the 6-conductor cord connecting to the radio transmitter and BC–121 control box. A 2 mfd. condenser is mounted in the base of the dynamotor. A view of the dynamotor unit is shown on Figure 41. The dynamotor unit measures 14⅝ inches high, not including plug; 11⅛ inches wide, including the heavy low-voltage terminals; and 13¾ inches long, and weighs approximately 70 pounds.

4. Radio transmitter BC–110.—The radio apparatus in radio transmitter BC–110 is mounted either on the bakelite panel or supported by a metal frame attached to the back of the panel. The panel is

removed from the wood box by removing the screws along the edge of the panel. The tube shelf is mounted on sponge rubber cushions to reduce the effects of vibration and shock. Five VT–4 tubes and one VT–2 tube are placed in the sockets mounted on the tube shelf. The tubes are surrounded by asbestos board shields to prevent the heat radiated from the tubes from injuring the wood box and bakelite panel. All cord connections to the radio transmitter are made to binding posts. The front of the panel carries the plate, filament, and antenna current ammeters. The radio transmitter measures 25 inches wide, including eyes; $11\frac{5}{16}$ inches deep, and $17\frac{3}{8}$ inches high, and weighs 50 pounds.

5. Views of the radio transmitter are shown on Figure 37 and Figure 38. The apparatus legend is the same as used in the circuit diagrams shown later in this pamphlet. In the production sets the scale provided for the master oscillator variometer is calibrated in kilocycle wave frequency instead of wave length in meters as shown on Figure 38.

APPARATUS LEGEND

A_1 =Thermoammeter, 0 to 5 amperes; antenna current.
A_2 =D. C. ammeter, 0 to 25 amperes; filament current.
A_3 =D. C. ammeter, 0 to 1.5 amperes; plate current.
C_1 =0.005 m. f. condenser.
C_2 =0.005 m. f. condenser.
C_3 =0.00095 m. f. condenser.
C_4 =0.0011 m. f. condenser.
C_5 =0.005 m. f. condenser.
C_6 =0.002 m. f. condenser.
C_7 =0.002 m. f. condenser.
C_8 =0.002 m. f. condenser.
C_9 =0.002 m. f. condenser.
C_{10} =0.004 m. f. condenser.
C_{11} =0.00025 m. f. condenser.
R_1 =250-ohm resistance.
R_2 =10,000-ohm resistance.
R_3 =2.5-ohm resistance.
R_4 =12,000-ohm resistance.
R_5 =0.5-megohm resistance, type RS-1.
R_6 =Filament rheostat.
F =Fuse, 2 amp. 2,000 volts.
R_7 =200-ohm resistance.
R_8 =180-ohm resistance.
R_9 =500-ohm resistance.
R_{10} =200-ohm resistance.
R_{11} =5,000-ohm resistance.
L_1 =Audio frequency choke coil.
L_2 =Choke coil, type C–53.
L_3 =Choke coil, type C–54.
L_4 =Antenna tuning variometer.
L_5 =Amplifier grid coupling coil.

L_6 =Oscillating circuit variometer.
T_1 =Antenna output transformer.
T_2 =Modulation transformer, type C–50.
T_3 =Tone circuit transformer, type C–52.
T_4 =Microphone transformer, type C–51.
S_3 =A, B, C, D, E, H, J, K, L, 3-pole double-throw switch.
W =Jack for microphone.
S_1 =Transmitter control switch.
S_2 =Tone control switch.

6. **Radio control box BC–121.**—This control box is intended for the use of the radio operator. It contains a magnetically operated transmit-receive switch which is controlled by the three-position switch provided with large knob on the front of the panel. When the switch is in the middle position the operator is connected to the interphone system. The control box contains the sending key controlled relay S_4, and the relay controlling the receiver filament circut S_5. Plugs and sockets are provided for the connections to other parts of the radio set and to the interphone set. Delco spring binding posts are provided for the high voltage connections to the control box. Jacks are provided for connection of the radio operator's microphone and headset. The control box measures 9 inches wide, $11\frac{1}{8}$ inches high, including high voltage binding posts but not including plugs, and $5\frac{7}{8}$ inches deep, including switch knob, and weighs 8 pounds without plugs.

7. Views of the BC–121 control box are shown on Figure 33 and Figure 34. The apparatus legend is the same as used in the circuit diagrams shown later in this pamphlet.

APPARATUS LEGEND

S_4 =Telegraph key—magnetic type.
S_5 =Control switch for receiver filament circuit.
S_6 =Transmit and receive switch.
S_8 =Transmit and receive switch—magnetic type.

8. **Radio control box BC–120.**—This control box is intended for use by the flight commander who will be remote from the radio transmitter. The front of the panel carries a knob for operating a switch marked "Transmit-Receive." Turning this switch causes the magnetically controlled switch in the BC–121 to operate. A plug and socket are provided for the cord connection to the BC–121 control box. A plug and socket are provided for connection of a telegraph sending key for use of the flight commander. The BC–121 control box measures $4\frac{3}{4}$ inches wide, $5\frac{15}{32}$ inches high, not including plugs, and 5 inches deep, including switch knob, and weighs $1\frac{1}{2}$ pounds.

9. Views of the BC–120 control box are shown on Figure 39 and Figure 40.

10. Interphone control box BC–123.—The interphone control box is intended for use by the flight commander. It includes a switch so that the flight commander can connect his microphone and headset either to the interphone set or to the radio set. Plugs and sockets are provided for the two 4-conductor cord connections to the BC–121 radio control box. They are colored and numbered to aid in their easy identification. Jacks are provided for connection of the flight commander's microphone and headset. The control box measures 6½ inches wide, 4⅛ inches high, not including plugs, and 5½ inches deep, including switch handle, and weighs 2½ pounds without plugs.

11. Views of the BC–123 control box are shown on Figure 44 and Figure 42.

12. Interphone jack box BC–126.—This is a bakelite box in which are mounted a microphone and telephone jack enabling as many of these interphone extension stations as desired to be connected in parallel across the interphone circuit. Views of BC–126 jack box are shown on Figure 43.

13. Installing the set.—Detailed instructions for the installation of the set in various types of planes, including description of trailing wire antenna to be used, will be issued from time to time by the Air Service. The cording diagram of the SCR–135 radio set and SCR–155 interphone set is shown on Figure 26. The various types of multiconductor cable required in wiring the SCR–135 set according to Figure 26 are called for in the parts list. The conductors that connect to plugs are to be carefully soldered to copper terminals, Belden code Nabob. The ends of the terminals are to be firmly pressed around the rubber insulation, so that no bending can occur where the bared conductor is soldered to the terminal. If the terminals are found to work loose under the fastening screw of the plug contact stud, the terminals may be sweated to the plug contact studs or small lock washers provided. The various conductors must be carefully identified at the two ends of the cable, using a buzzer, headset, or other convenient means, in order that a conductor may connect to the same numbered plug contact stud at each end. The single conductor wire W–65 is to be provided with the Delco terminals No. 20953. The end of the terminals is to be formed around the rubber insulation and then securely bound to the insulation by means of heavy thread, afterwards varnished to prevent slipping. The cable conductors connecting to the BC–110 transmitter are also to be equipped with the Delco terminals No. 20953. The two conductors connecting the BD–43 directly to the BC–121 are to be spliced together at the radio transmitter.

14. Operation and care of the set.—The radio transmitter BC–110, radio control box BC–121, and receiving tuner BC–115 are located

in the plane in a location accessible to the radio operator. Throwing the transmit-receive switch on either radio control box to "Transmit" causes the relay on the dynamotor unit to close, starting up the dynamotor and lighting the transmitter tube filaments. Throwing the switch to "Receive" causes a relay in the BC–121 to close, lighting the tubes in the receiver. The operation of the transmit-receive switch causes also the magnetically controlled switch in the BC–121 to connect the antenna either to the radio transmitter or the radio receiver. The BC–121 contains a telegraph sending relay controlled by a telegraph key connected to the two-point socket of either the BC–120 or BC–121 control box. The switch S_7 is a single pole knife switch at the top of the BC–121. This should be closed only when the BC–120 is not used. The radio operator using the BC–121 is only able to control the magnetically operated transmit-receive switch when the switch on the BC–120 is at "Off" or when S_7 in BC–121 is closed. This is provided so that the flight commander when operating the radio set by means of BC–120 has full control independent of the position the operator at the BC–121 may have his transmit-receive switch. The radio transmitter BC–110 is designed to permit remote operation of the radio transmitter. The binding post marked "Antenna-Remote" uses a tap on the antenna loading inductance, so that fine tuning of the antenna circuit may be made, using a variometer at the remote control point. The switch on the transmitter panel marked "Transmitter control" disconnects the antenna current ammeter from the ground, so that another ammeter may be connected at the remote control point between the key circuit and the ground. The remote control provision is not used in the SCR–135 installation. In the SCR–135 set, if the transmitter-control switch is placed on remote and operation attempted, the insulation in BC–121 will break down.

15. Before leaving the ground the radio set should be tested by connecting a phantom antenna consisting of a capacity of 350 mmf. (capable of withstanding 10,000 volts R. M. S.) and a noninductive resistance of 4 ohms between the antenna binding post on the under side of the BC–121 control box and the ground connection to the plane. Adjustments are then made as described below. If interrupted continuous wave telegraph is to be used, it should be noted that the antenna current increases slightly when the switch marked "Tone control" on the BC–110 is moved from C. W. to one of the tones. If telephone operation is to be used, it should be noted that the antenna current increases slightly when the microphone is spoken into. These tests determine whether the set is modulating properly. The antenna tuning adjustment used in the ground test is not correct when using the airplane trailing wire antenna, and therefore the

antenna circuit must be carefully tuned again when the airplane is in the air. The trailing wire antenna is carried on an antenna reel and is let out by the radio operator after the airplane has reached sufficient altitude.

16. Procedure by radio operator.—*a.* Turn master oscillator pointer to wave frequency desired and fix setting by means of the locking device.

b. Turn switch on BC–110 to telegraph or telephone, as desired.

c. If telegraph is to be used, turn switch marked "Tone control" to proper tone A to E, or to C. W. for continuous wave communication. Tone A is the highest and tone E is the lowest pitch. The various tones are provided for use when interference is experienced, so that the tone most easily read through the interference may be selected.

d. Turn switch on BC–110 marked "Transmitter control" to "Direct."

e. Place 5 VT–4 tubes and 1 VT–2 tube in the sockets. Type VT–4–A tubes have a letter added to the serial number on the glass bulb indicating the filament rating of the tube. The two tubes used as power amplifiers should have the same filament rating letter. The two modulator tubes should also have the same filament rating letter. This is necessary in order that tubes that are in parallel will divide the load equally.

f. Turn transmit-receive switch on BC–121 to "Transmit," which will cause the dynamotor unit relay to close, starting up the dynamotor. (The switch on BC–120 must be off otherwise the operator using the BC–121 will have no control of the radio set.)

g. Adjust filament rheostat until a filament current of 18.4 amperes is obtained. This total current is required when Western Electric Co. type VT–4–A tubes which have a nominal rating of 3.4 amperes are used. When General Electric Co., or other make, type VT–4–B tubes which have a nominal rating of 3.25 amperes are used, the total filament current should be 17.6 amperes.

h. Tune variometer on BC–110 marked "Antenna tuning" until maximum reading of the antenna current ammeter is obtained. The antenna current should be about 4 amperes and the plate current about 0.85 amperes.

i. For receiving, turn transmit-receive switch on BC–121 to "Receive" and adjust antenna tuning and heterodyne on BC–115 receiving tuner, as described in the instruction pamphlet covering the receiving equipment.

j. To report to the flight commander, the operator will turn the switch on the BC–121 to the middle point marked "Interphone," as the flight commander will ordinarily be connected across the interphone system. All adjustments of the radio set are made by the operator and contact established with the radio station to be communicated with before the operator reports to the flight commander that the set is ready for his use.

k. The radio operator will ordinarily be standing by using the radio receiver, reporting to the flight commander occasionally for instructions.

17. Procedure by flight commander.—*a.* The flight commander will ordinarily be connected across the interphone system. The switch on the BC–120 radio control box is then at "Off," and the switch on the BC–123 interphone control box is on "Interphone."

b. When the flight commander desires to talk to the radio operator, he should instruct the rear gunner or other convenient person, by interphone, to indicate to the radio operator that he should turn the switch on the BC–121 to "Interphone." Or the flight commander may call the radio operator through his radio tone telegraph or telephone side tone by putting BC–123 switch on "Radio" and BC–120 switch on "Transmit."

c. When the flight commander desires to operate the radio set himself, the radio operator will first establish contact with the radio station to be communicated with the then report to the flight commander by interphone. The flight commander then turns the switch on BC–123 to "Radio" and the switch on BC–120 to "Transmit" or "Receive" as desired.

PRINCIPLES EMBODIED IN THE SET AND THE CIRCUIT DIAGRAMS

18. Dynamotor unit BD–43.—Circuit diagram of the dynamotor unit is shown on Figure 31. The motor of the dynamotor and the filament circuit of the radio set are supplied from the 12-volt storage battery forming part of the central power plant on the airplane. The motor is started by the closing of the relay mounted on the panel above the dynamotor. The relay contacts also close the filament current supply circuit. The relay winding is controlled by the transmit-receive switch in either radio control box. The field winding of the motor also supplies the excitation for the high-voltage generator. A 2 M. F. condenser is connected across the high-voltage armature for the purpose of smoothing out variations in output due to commutation. The high-voltage generator supplies the plate current for all the tubes.

19. Radio transmitter BC–110.—Circuit diagram of the radio transmitter is shown on Figure 29. A complete schematic diagram of the transmitting equipment connected for telephone operation is shown on Figure 35. A similar schematic diagram showing connections for telegraph operation is provided on Figure 36. The ap-

paratus legend is the same as used for the other diagrams and photographs in this pamphlet showing the same equipment.

APPARATUS LEGEND

A_1 =Thermoammeter, 0 to 5 amperes; antenna current.
A_2 =D. C. ammeter, 0 to 25 amperes; filament current.
A_3 =D. C. ammeter, 0 to 1.5 amperes; plate current.
C_1 =0.005 M. F. condenser.
C_2 =0.005 M. F. condenser.
C_3 =0.00095 M. F. condenser.
C_4 =0.0011 M. F. condenser.
C_5 =0.005 M. F. condenser.
C_6 =0.002 M. F. condenser.
C_7 =0.002 M. F. condenser.
C_8 =0.002 M. F. condenser.
C_9 =0.002 M. F. condenser.
C_{10} =0.004 M. F. condenser.
C_{11} =0.00025 M. F. condenser.
F =Fuse, 2 amp., 2,000 volts.
R_1 =250-ohm resistance.
R_2 =10,000-ohm resistance.
R_3 =2.5-ohm resistance.
R_4 =12,000-ohm resistance.
R_5 =0.5-megohm resistance, type RS–1.
R_6 =Filament rheostat.
R_7 =200-ohm resistance.
R_8 =180-ohm resistance.
R_9 =500-ohm resistance.
R_{10} =200-ohm resistance.
R_{11} =5,000-ohm resistance.
L_1 =Audio-frequency choke coil.
L_2 =Choke coil, type C–53.
L_3 =Choke coil, type C–54.
L_4 =Antenna tuning variometer.
L_5 =Amplifier grid coupling coil.
L_6 =Oscillating circuit variometer.
T_1 =Antenna output transformer.
T_2 =Mondulation transformer, type C–50.
T_3 =Tone circuit transformer, type C–52.
T_4 =Microphone transformer, type C–51.
S =Relay contacts BD–43.
S_1 =Transmitter control switch, BC–110.
S_2 =Tone control switch, BC–110.
S_3 =A, B, C, D, E, H, J, K, L, 3-pole double-throw switch on BC–110.
S_4 =Telegraph key—magnetic type, BC–121.
S_6 =Transmit and receive switch, BC–121.
S_8 =Transmit and receive switch—magnetic type, BC–121.
W =Jack for microphone.

NOTE.—The portions of the schematic diagrams to the left of the vertical dash line passing through the core of transformer T_2, are exactly the same. When using telephone, the telegraph sending key is short-circuited by S_3.

20. Master oscillator.—The master oscillator—power-amplifier circuit—is used. The master oscillator is a Colpitts' type circuit formed by condensers C_3 and C_4 and variometer inductance L_6. The condenser C_2 is a blocking condenser to keep the direct plate current from the tube grid. The radio-frequency choke coil L_2 prevents the short circuit of the radio-frequency voltage through the plate voltage generator to the filament. The radio-frequency choke coil L_3 performs a similar function in the grid circuit. The large grid leak resistance R_{11} operates with the grid condenser C_2 to provide a negative grid biasing potential by accumulative rectification of the radio-frequency energy since the grid takes current during only the positive half of the cycle.

21. Power amplifier.—The power amplifier, consisting of two VT–4 tubes connected in parallel, is excited by the radio-frequency voltage supplied by the master oscillator. This voltage is induced in the winding L_5 which is wound directly over the master oscillator variometer L_6. The radio-frequency voltage is amplified by the power amplifier tubes so that the plate current to these tubes has a large radio-frequency component. This radio frequency energy is transferred to the antenna circuit by means of the air core antenna or output transformer T_1. The primary (plate) winding consists of a large inductance so designed as to offer large reactance to the radio-frequency current over the wave frequency band covered by the radio transmitter. This prevents the power amplifier taking excessive plate current when the antenna circuit is detuned. The secondary (antenna) winding consists of a small number of turns, so that the small radio-frequency current and large voltage operating through the tube plate to filament impedance is stepped down to a large radio-frequency current and small voltage which is more suitable for supplying current to the low-resistance antenna. The antenna circuit is tuned to resonance by means of the tapped inductance and variometer L_4 in order to obtain maximum antenna current as indicated by the radio-frequency ammeter on the radio transmitter.

22. The resistance R_1 in the grid circuit of the power amplifier tube is for the purpose of reducing the grid current flowing in the power amplifier tube during the positive half cycle. Otherwise this grid current is particularly large during the interval due to the plate audio modulation when the effective plate voltage is low. This varying load on the master oscillator circuit changes the wave frequency slightly which is objectionable. The grid of the power amplifier tube is kept at a negative bias potential by means of the accumulative rectification in the grid circuit of the radio-frequency excitation provided by the master oscillator. Condenser C_5 acts

as the grid condenser and resistances R_7, R_8, and R_9 act as the grid leak in this case. The resistances are tapped so that part of the negative potential built up across them may be used for negative biasing the grids of the voice amplifier and modulator tubes. The plate current for the power amplifier tube is supplied through the iron core choke coil L_1. The condenser C_1 provides a low-reactance bypass so that the radio-frequency component of plate current need not pass through the choke coil.

23. Telegraph keying.—The telegraph sending key relay operates to short-circuit a resistance R_{10} and condenser C_{11}, which are connected in the ground lead. With the key up the resistance and condenser reduce the antenna current to a very small value by a combined effect of inserting a large resistance and at the same time detuning the antenna circuit from the master oscillator. The combination is such that minimum sparking occurs at the key-relay contacts. With the key relay open the load will be removed from the power amplifier plate circuit so the plate current will also be reduced. This method of keying is used for both C. W. telegraph and I. C. W. telegraph. For telephone operation the resistance and condenser are short-circuited by the switch S_3.

24. Telephone modulation.—The connections are shown on Figure 35. The microphone transmitter is in series with the primary of transformer T_4 and utilizes the voltage drop across the VT–2 tube for power supply. The microphone T–11 is equipped with an open-circuiting switch mounted on the stem. The alternating-current voltage due to the voice is stepped up by the transformer and then impressed on the grid of the VT–2 voice amplifier. The secondary of the step-up transformer T_4 has connected across it a leak type resistance R_5 which serves to improve the modulation and prevent grid blocking, especially if the grid is caused to go positive by excessive modulation. A steady negative biasing potential is supplied the grid of the VT–2 tube by utilizing the voltage developed across resistance R_7, as explained previously. The audio-frequency voltage on the voice-amplifier grid is repeated in amplified form in the plate circuit. The plate current for this tube is supplied from the 800-volt dynamotor armature, and is therefore passed through the resistance R_2 in order to reduce the effective voltage to a suitable value for the VT–2 tube. The plate circuit also contains the primary of the one-to-one ratio transformer T_2, which transfers the audio-frequency voltage to the grid circuit of the VT–4 modulator tubes.

25. Tone telegraph modulation.—The same VT–2 tube which is used as a voice amplifier for telephone operation is also connected by means of switch S_5 for use as an audio-frequency oscillator for I. C. W. modulation. The circuit arrangement is shown on Figure

36. The tuned plate circuit consists of the windings of transformers T_2 and T_3 and condensers C_6, C_7, C_8, C_9, C_{10}, which provide variation of capacity in fixed steps so as to provide five different tone frequencies. Feed-back couplings from the plate to the grid necessary for maintenance of oscillations is provided by the transformer T_3. In order to secure C. W. telegraph operation it is only necessary to stop the audio oscillator, which is accomplished by short-circuiting the capacity by means of switch S_2.

26. Side tone circuit.—The quality and presence of telephone or tone telegraph modulation so far in the circuit is assured the operator by hearing his own signal by means of the side tone circuit provided. This connects the modulator grid through the telephone head set plugged into the radio-control box, completing the circuit through the 60-volt receiver plate battery to the receiver ground connection. The side tone circuit contains a condenser in order to block any direct-current flow, and also to moderate the volume of side tone so as to be suitable for the head set.

27. Modulator tubes.—Two VT–4 tubes are connected in parallel for use as modulators. The audio frequency voice or tone modulation is impressed on the grid of the modulator tube by means of the one-to-one ratio transformer T_2. The secondary of the transformer T_2 has connected across it a resistance R_4 which serves to improve the modulation and prevent grid blocking. A steady negative biasing potential is supplied the modulator grid by utilizing the voltage developed across resistances by R_7 and R_8 as explained previously.

28. Modulation of radio-frequency output.—The audio-frequency voltage on the modulator grids is repeated in amplified form in the plate circuit. This plate circuit is supplied from the 800-volt dynamotor armature, the plate current passing through the large iron core inductance L_1. The plate current for the power amplifier tubes also passes through this choke coil. The choke coil has large audio-frequency reactance, and therefore tends to maintain the total plate current at a constant value. For instance, during the audio-frequency positive half cycle when the modulator plate current increases the power amplifier plate current decreases so that the total current remains nearly constant. The audio-frequency modulation therefore causes the power amplifier plate current (or effective plate voltage) to increase and decrease following the wave form of the original modulation. The radio transmitter is so designed that the radio-frequency output of the power amplifier is directly proportional to the plate current (or effective plate voltage). The audio-frequency variations in the plate current thus cause corresponding variations in the radio-frequency output effecting the desired audio-frequency modulation of the radio-frequency wave.

45027—25——3

29. Filament circuit.—The filament circuit of all the tubes are supplied in parallel from the 12-volt line. The VT–2 tube circuit contains a fixed resistance R_3 which fixes the filament current at the proper value for this tube. A rheostat R_6 controls the total filament current, permitting the obtainment of proper filament current for a considerable range of supply voltage.

30. Radio control box BC–121.—The circuit diagram is shown on Figure 27. The function and operation of the various parts has been described previously. The magnetically controlled transmit-receive swith S_8 is of the impulse type in that it takes current only during the time required to operate the switch. The key relay S_4 provides convenient control by means of low-voltage circuits of the high-voltage radio-frequency antenna current. The magnetic switch S_5 closes the radio-receiver filament circuit when the transmit-receive switch is turned to "Receive." The power supply for the three magnetically controlled switches is provided by a connection from the BC–121 to the BD–43 positive 12-volt binding post.

31. Radio control box BC–120.—The circuit diagram is shown on Figure 28. The single pole double throw switch provided enables the magnetically controlled transmit-receive switch to be controlled at a distance from the BC–121.

32. Interphone circuit—General.—All the interphone stations are connected in parallel across a three-wire line as shown on Figure 26. The microphones are each connected with 22 ohms in series across the black and green conductors and the telephone headsets are connected across the black and red conductors. A 12-volt storage battery is to be connected to the BC–123 interphone control box. All power to the interphone circuit is cut off when the switch on the BC–123 is turned to "Off." The T–11 microphones are provided with open-circuiting switch mounted on the stem, so that interfering noises will not be impressed on the interphone circuit when unnecessary.

33. Interphone control box BC–123.—The circuit diagram is shown on Figure 30. The microphone current passes through the primary of a step up ratio induction coil. The higher voltage induced in the secondary supplies the headsets connected in parallel.

34. Interphone jack box BC–126.—The circuit diagram is shown on Figure 32. The microphone transmitter, with a 22-ohm resistance in series, is connected across the interphone circuit by means of the jack provided. A jack is also provided for connecting a telephone headset.

35. The SCR–135 transmitting and receiving equipment is calibrated in kilocycles. It will be noted that for frequencies up to 1,500 kilocycles the frequency is given in equally spaced divisions, as

the frequency separation is an indication of the amount of interference to be expected between two stations.

36.

Parts list for airplane radio telephone and telegraph set, type SCR–135

Quantity	Unit	Material	Manufacture according to—
1		Radio transmitter, type BC–110	Spec. 71–51–B.
10		Tubes, type VT–4B; 5 in use, 5 spare	Spec. 71–179–E.
2		Tubes, type VT–2; 1 in use, 1 spare	Spec. 2113–A.
1		Radio control box, type BC–120	Spec. 71–59–A.
1		Radio control box, type BC–121	Spec. 71–181–B.
1		Headset, type HS–14 (or HS–12)	Spec. 71–210.
1		Transmitter, type T–11, microphone	Spec. 71–190.
2		Keys, type J–5	Spec. 3081.
1		Radio receiving tuner, type BC–115	Spec. 71–58–A.
1		Radio audio-frequency amplifier, type BC–116	Spec. 71–57–C.
1		Plug, type PL–11	Comm. standard.
2		Terminals, type TM–50, for use with PL–11	Comm. standard.
16		Tubes, type VT–5; 8 in use, 8 spare	Spec. 71–178.
9		Batteries, type BA–2; 3 in use, 6 spare	Spec. 70–21.
1		Battery box, type BC–128	Spec. 71–199.
[1] 30	Foot	Cord, type CO–100, 2-conductor No. 18	Spec. 71–158–B.
[1] 20	Foot	Cord, type CO–102, 4-conductor No. 18	Spec. 71–158–B.
[1] 35	Foot	Cord, type CO–110, 6-conductor No. 18, shielded	Spec. 71–211–A.
[1] 25	Foot	Cord, type CO–111, 2-conductor No. 10, 4-conductor, No. 18 shielded	Spec. 71–212–A.
[1] 20	Foot	Cord, type CO–113, 2-conductor No. 18, shielded	Spec. 71–211–A.
[1] 60	Foot	Wire, type W–65, single-conductor	Spec. 71–160.
1		Terminal, type TM–92, positive, for receiver cord	Dwg. RLD–917–A.
1		Terminal, type TM–93, negative, for receiver cord	Dwg. RLD–917–A.
2	Piece	Soft rubber tubing, ⅛ by ¼ by 6 inches long, for receiver cord	
2		Tinned copper sleeves, for receiver cord, item 5 of	Dwg. RLD–5544–A
25		Terminals, type TM–94	Comm. standard.
50		Terminals, type TM–95	Comm. standard.
1		Dynamotor unit, type BD–43	Spec. 71–180–A.
3		Batteries, type BB–4, 4-volt storage, 1 in use, 2 spare	From stock.
2		Drums, type DR–2; 1 in use, 1 spare	Dwg. RLC–371.
2		Fairleads, type F–5; 1 in use, 1 spare	Spec. 2068.
1		Reel, type RL–2	Dwg. RLD–369.
20	Foot	Rope, type RP–11	Comm. standard.
10		Weights, type WT–1, 1 in use, 9 spare	RL–SK–1012.
3,000	Foot	Wire, type W–5	Spec. 3005.

[1] Cords will be issued in long lengths and cut for exact requirements at time of installation.

NOTE.—The 12-volt storage battery for operating the radio transmitter, and the 2-conductor No. 2 B. & S. twin conductor cable connecting to the dynamotor unit will be provided by the Air Service.

Parts list for airplane interphone set, type SCR–155

Quantity	Unit	Material	Manufacture according to
4		Head sets, type HS–14 (or HS–12)	Spec. 71–210.
4		Transmitters, type T–11, microphone	Spec. 71–190.
1		Interphone control box, type BC–123	Spec. 71–184–A.
3		Interphone jack boxes, type BC–126	Spec. 71–185–A.
[1] 50	Foot	Cord, type CO–109, 4-condr., No. 18, shielded	Spec. 71–211–A.
[1] 30	Foot	Cord, type CO–112, 3-condr., No. 18, shielded	Spec. 71–211–A.
[1] 10	Foot	Cord, type CO–113, 2-condr., No. 18, shiedled	Spec. 71–211–A.
10		Terminals, type TM–95	Comm. standard.

[1] Cords will be issued in long lengths and cut for exact requirements at time of installation.

NOTE.—The 12-volt storage battery will be provided by the Air Service.

RECEIVING EQUIPMENT FOR SCR–133, SCR–134, AND SCR–135—AIRPLANE RADIO TELEPHONE AND TELEGRAPH SETS

1. Purpose of set.—The same radio receiving equipment is used installed in airplanes as part of the SCR–133, SCR–134, and SCR–135 sets. The SCR–133 set is a 5-mile range interplane radio-telephone set. The SCR–134 is a 30-mile corps observation-plane set intended to work with ground stations for long-range artillery fire control, etc. The SCR–135 is a 100-mile army airplane set intended for installation on large bombing-type planes. The wave-frequency range of the receiving equipment is 250 to 1,500 K. C. The receiver is of the superheterodyne type and provides for telephone and I. C. W. telegraph reception, but not for C. W. telegraph.

GENERAL DESCRIPTION OF RECEIVING EQUIPMENT

2. Parts.—A 4-volt storage battery is provided for supplying the filament circuit. The plate battery is 3 BA–2 batteries in series (60–V), contained in a BC–128 battery box. The antenna lead connects to the receiving tuner which contains an antenna tuning system and a separate heterodyne circuit. The combined wave frequencies of the signal and the heterodyne are carried to the amplifier unit where proper rectification and radio and audio-frequency amplification are obtained. The receiving tuner is the only part of the receiving equipment which is installed in the rear cockpit, and which is therefore accessible to the observer who operates the set. The filament rheostat controlling all the receiving-tube filaments is therefore located on the tuner panel. The head-set connection to the amplifier is made through cord connection to the radio-control box which is also installed in the rear cockpit. The send-receive switch is installed in this radio-control box. All parts of the receiving equipment are connected with multiconductor cords terminated with specially-designed plugs indicated on Figures 10, 17, and 26.

3. Radio receiving tuner BC–115.—Two sides of the receiving tuner are bakelite panels. The other four sides are covered by the wood box. The receiving tuner is 6½ inches wide, 7⅜ inches high (including tube shield), and 5½ inches deep (including binding posts). The tuner weights 5 pounds without plug.

4. A front view of the tuner is shown on Figure 52. The knob to the left varies the condenser and variometer comprising the antenna

tuned circuit. This knob operates through suitable gears to obtain slow motion of the dial on the condenser shaft. This scale is marked "Antenna tuning" and is divided into degrees of a circle. The knob to the right turns the separate heterodyne variable condenser through suitable gears to obtain slow motion of the dial on the condenser shaft. The scale reads directly in kilocycles by multiplying the reading by 100. On the lower part of the front panel is a metal cap which is lifted to insert the VT–5 heterodyne oscillator tube in its socket. The filament rheostat is contained in the large knob, the edge of which is seen below the panel. Numbers are engraved along the edge of the rheostat knob to indicate the position of the rheostat. The series resistance decreases and the filament current increases as the number indicated on the knob increases.

5. A view of the under panel is shown on Figure 53. This view shows the 4-point socket providing for connection to the amplifier for filament and plate power supply, and two Delco binding posts to connect the signal voltage from the radio control box to the receiving tuner, and from the receiving tuner to the amplifier.

6. The apparatus installed inside the tuner is shown on Figure 50. The apparatus legend which follows uses the same symbols as the circuit diagram shown later in this pamphlet:

C =Tuner condenser, 600 m. m. f.
C_1 =Heterodyne condenser, 600 m. m. f.
C_2 =Fixed condenser, 10,000 m. m. f.
C_3 =Fixed condenser, 150 m. m. f.
L =Tuner variometer.
L_1 =Grid inductance.
L_2 =Plate inductance.
R_1 =Filament resistance, 6.5 ohms.
R_2 =Resistance, 100,000 ohms.

7. Radio-audio-frequency amplifier BC–116.—The amplifier consists of a bakelite panel with a bakelite shelf carrying the tubes, transformers, etc., supported on sponge rubber cushions on metal brackets fastened to the back of the panel. The panel and entire apparatus is removed from the box by turning the two panel locks to a horizontal position, pulling the panel forward by means of the lock handles, and lifting the panel upward off the supporting pins at the sides of the box. The amplifier is 15⅛ inches wide, including eyes, $8\frac{13}{16}$ inches high, and 5 inches deep overall. The amplifier weighs 9 pounds without plugs or tubes.

8. A front view of the amplifier is shown on Figure 48. The two panel locks are along the upper edge of the panel. Delco binding posts at the left of the panel provide for connection of signal voltage from the receiving tuner to the amplifier, and the ground connection to the amplifier. One 4-point socket marked "Receiving tuner"

supplies filament and plate power to the tuner. The 4-volt storage battery for filament supply and 60-volt battery for plate supply connect to the amplifier 4-point socket marked "Plate and filament batteries." A 2-point socket on the amplifier provides for completion of the filament circuit through the send-receive switch on the radio control box, so that the receiver tubes are only lighted when the switch is thrown to "Receive." Telephone jacks are mounted on the panel, so that either one or two stages of audio-frequency amplification can be used as desired.

9. A view of the apparatus on the back of the panel is shown on Figure 49. The apparatus legend which follows uses the same symbols as the circuit diagram shown later in this pamphlet.

C =Condenser, 150 m. m. f.
C_1 =Condenser, 1,500 m. m. f.
C_2 =Condenser, 5,000 m. m. f.
C_3 =Condenser, 10,000 m. m. f.
J =Telephone jack.
R =0.5 megohm resistance, type RS–1.
R_1 =2.0 megohm resistance, type RS–3.
R_2 =7.0 ω resistance.
T =Transformer, type C–56.
T_1 =Transformer, type C–59.
T_2 =Transformer, type C–21–B.
V =Vacuum tube, type VT–5.
Vl =Detector.
Vr =Radio frequency, Amplifier.
Va =Audio frequency, Amplifier.

10. Battery box, type BC–128.—This battery box contains the 3 BA–2 batteries supplying the plate current for the receiving equipment. The box is 7–9/64 inches long, $3\frac{15}{16}$ inches high including binding posts, and $3\frac{7}{8}$ inches wide. The box weighs 4 pounds with batteries. The box is shown on Figure 51.

INSTALLING THE RECEIVING EQUIPMENT

11. Detailed instructions for the installation of the receiving equipment in various types of planes will be issued from time to time by the Air Service. The cording diagram for the receiving equipment is the same for the SCR–133, SCR–134, and SCR–135 sets. The cording diagram for the SCR–134 set is shown on Figure 17. When the SCR–160 interphone equipment is to be used in connection with the radio set, cords CD–98 and CD–99 are plugged into the jacks of the BC–119 control box in place of the headset and microphone plugs. The complete cording is shown on Figure 16. The use of the adapters enables either new or old type microphones and head sets to be used, depending upon which is available. The material listed in the interphone equipment parts list is the additional equipment required if the interphone is to be used. The various types of multiconductor cable required in wiring the SCR–134 set according to Figure 17 are called for in the parts list. The conductors are to be carefully soldered to copper terminals, Belden code "Nabob." The ends of the terminals are to be firmly pressed around the rubber insulation so that no bending can occur where the bared conductor is soldered to the terminal. If the terminals are found to work loose under the fastening screw of the contact stud, the terminals may be sweated to the plug contact studs or small lock washers provided. The various conductors must be carefully identified at the two ends of the cable, using a buzzer, headset, or other convenient means, in order that a conductor may connect to the same numbered plug contact stud at each end. The single conductor wire W–65 is to be provided with the Delco terminals No. 20953. The end of the terminal is to be formed around the rubber insulation and then securely bound to the insulation by means of heavy thread, afterwards varnished to prevent slipping.

OPERATION AND CARE OF RECEIVING EQUIPMENT

12. Filament adjustment.—When the send-receive switch in the radio control box is turned to receive, the antenna is connected to the receiver, and also the receiver filament circuit is closed (if tuner rheostat is not on "Off"). The tuner rheostat is then turned to the proper position for obtaining normal filament current. The position of the rheostat, of course, depends upon the state of charge of the storage battery. An indication of the proper filament current is obtained by lifting the metal cap over the oscillator tube on the tuner and observing the brightness of the filament. The VT–5 tubes have a coated filament which should burn at a cherry red color. If signals are being received, the rheostat should be turned to reduce filament current until the signal just begins to weaken. The life of the tubes is greatly shortened by burning them too bright. The amplifier tubes are connected so that the first three tubes are in series across the supply voltage, as are also the second three tubes. When one of these tubes burns out the other two will also fail to burn. The tubes can be tried in the second audio tube socket until the defective tube is located, as this second audio tube operates directly from the filament supply. The total filament current should be 1 ampere.

13. Tuning.—Tuning adjustments are made by means of the knobs on the receiving tuner marked "Tuner" and "Heterodyne." The heterodyne knob is turned until its scale reads the kilocycle wave frequency of the station to be received. The tuner knob is then turned until the signal is picked up. The knob must be turned

slowly as the tuning is very sharp. If the signal is not picked up by this operation, turn the heterodyne slightly first in one direction and then in the other direction varying the tuner through the proper range each time. When the tuner is adjusted for best signal, go back to the heterodyne and slightly readjust that to see if any improvement can be obtained. It is well to record the "Tuner" settings for various "Heterodyne" settings, which will be of great value when receiving using the same antenna.

14. When it is necessary to receive a station the wave frequency of which is not known, the finding of the station is a rather long and uncertain task. The heterodyne is progressively moved in short steps, each time turning the "Tuner" through a range suitable for receiving the wave frequency indicated on the heterodyne. If this approximate calibration of the tuner is not known, it is necessary to turn the tuner adjustment through its whole range for each setting of the heterodyne. When the desired signal is picked up and the best tuner adjustment obtained, the heterodyne should also be readjusted slightly to obtain any possible improvement. It is usually possible to find two heterodyne settings for a certain tuner setting. The calibration on the heterodyne scale is in all cases for the adjustment using minimum setting of the heterodyne condenser; i. e., the adjustment having the higher kilocycle reading. The higher kilocycle reading is then the wave frequency of the received signal. (See conversion table.)

15. Shielding of ignition system.—The airplane ignition system must be carefully shielded to prevent the pick-up of disturbances which cause sounds similar to heavy static. The shielding is to be carried out and maintained in accordance with instructions to be issued by the Air Service. If great interference is experienced while in the air, the shutting off momentarily of the ignition system by the pilot will determine whether the ignition shielding has become faulty.

16. Use of receiver without transmitting equipment.—When the receiver is used solely and not operated in conjunction with transmitter or control box, a small fixed condenser should be inserted in series with the antenna binding post and the antenna to prevent grounding of the antenna, thereby causing the oscillator tube to be burned out due to the shorting out of the filament resistance.

17. Preliminary test.—The receiving equipment can be tested in the laboratory or after installation in the plane and before leaving the ground. An antenna consisting of a 15-foot length of wire is connected to the radio control box binding post marked "Antenna," or the receiving tuner binding post marked "Control box," in case the radio control box is not used. This small antenna is sufficient for picking up near-by stations and enables the receiving equipment to be tested before flight. If the same station is to be received in the

air, the heterodyne scale reading will be very nearly the same as used in the ground test, but, of course, the "Tuner" scale reading will be different because the airplane antenna has much greater capacity than the short wire antenna suggested for the ground test.

PRINCIPLES EMBODIED IN THE RECEIVING EQUIPMENT AND THE CIRCUIT DIAGRAMS

18. General principles.—The radio receiving equipment is of the superheterodyne type. The antenna circuit is tuned to the incoming signal. Loosely coupled with the antenna circuit is an oscillator or separate heterodyne circuit, the frequency of which is adjusted to obtain the desired frequency beat note with the signal frequency. This beat not is not an audio-frequency such as is obtained when a C. W. telegraph signal is heterodyned. Instead, a very high frequency of approximately 66.7 kilocycles (or 4,500 meters) is used. This frequency is selected as permitting the design of a very efficient radio-frequency amplifier. The amplifier operating on a fixed frequency of 66.7 kilocycles is far more efficient than any amplifier which could be designed to amplify directly the very high signal wave frequencies and covering a wide wave frequency band. The latter also would be more critical and would require a potentiometer or other means for controlling oscillations set up in the amplifier. The 66.7 kilocycle, or intermediate frequency amplifier is made very sharply resonant, which provides the great selectivity obtained. We have seen that the signal frequency and the heterodyne frequency are combined to provide a beat note corresponding to their difference in frequency, or 66.7 kilocycles. However, all we have done so far is to modulate the signal frequency at the rate of 66.7 kilocycles. This latter frequency is not available to the radio-frequency amplifier until the modulated wave is rectified, the same way ordinary audio-frequency is not available in an ordinary radio receiver until the wave frequency has been passed through the detector tube. Accordingly, the voltage due to the combined frequencies set up across the antenna tuning inductance is impressed upon a detector tube, which is the first tube in the BC–116 amplifier. The 66.7 kilocycle frequency obtained by this rectifying operation is then connected to the input of a three-stage radio-frequency amplifier. Three iron-core radio-frequency transformers, C–56, and one air core radio-frequency transformer, C–59, are used in the radio-frequency amplifier. The air core transformer, with the condenser across the secondary, is sharply tuned and determines the resonant frequency of the amplifier. The frequency carried through the amplifier consists of the 66.7 kilocycle radio-frequency and the audio-frequency modulation due to telephone or tone telegraph provided at the radio

45027—25——4

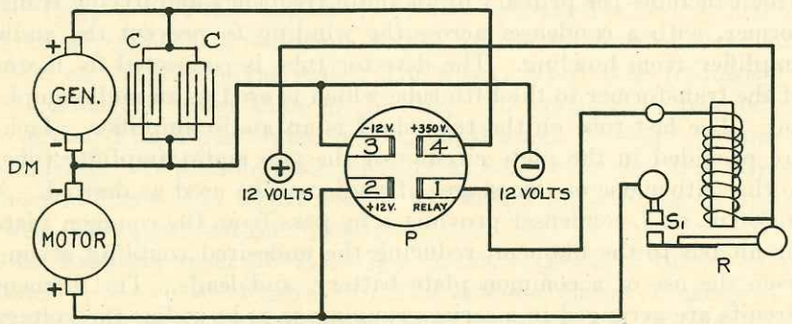
transmitter, which has persisted through all the transformations so far. In order to obtain the audio frequency it is necessary to again rectify the signal, so the output of the radio-frequency amplifier connects to a second detector tube. This recovers the audio voice or I. C. W. modulation, which is then passed through either one or two stages of audio-frequency amplification as desired, in order to secure sufficient volume to enable the signal to be heard above the wind and engine noises in the airplane.

19. Quite loud signals are usually required in the air in order to be audible above the engine and wind noises not entirely excluded by the receiver helmet, and the static and other interference picked up by the very sensitive receiving equipment. The receiving equipment is very selective which causes the elimination of most of the interference from radio sets operating on other wave frequencies. As the receiving equipment does not provide in any way for an audio-frequency beat note with the signal, it is impossible to receive C. W. telegraph signals. The heterodyne calibration does not show the frequency of the oscillator, but does indicate the proper heterodyne adjustment to receive a signal of the wave frequency indicated on the heterodyne scale. The actual heterodyne frequency is 66.7 kilocycles lower than the reading. In practice the heterodyne is adjusted until best signal is obtained through the radio-frequency amplifier. As the amplifier operates at 66.7 kilocycles, this adjustment indicates that a beat note of this frequency is being set up between the signal and the heterodyne.

20. Receiving tuner BC–115.—The circuit diagram of the receiving tuner is shown on Figure 46. The antenna circuit consists of a variable air condenser and variometer connected on the same shaft so as to turn together. The tuner rotary switch automatically connects the variable inductance and capacity in series for high wave frequencies, and in parallel for lower wave frequencies. The heterodyne oscillator circuit includes a fixed inductance and variable air condenser in the grid circuit. The fixed inductance has a tap used for the higher frequency scale, connected automatically by the heterodyne rotary switch. Fixed coupling is provided with an inductance in the plate circuit. The grid circuit includes a grid leak and condenser so that the radio-frequency oscillations build up a steady negative grid bias to reduce the oscillator plate current. The filament current is limited by means of a fixed resistance of 6.5 ohms, in series with the rheostat which controls all the receiving tubes together. The plate and filament supply for the oscillator is obtained from the amplifier BC–116 by means of the 4-point socket provided.

21. Radio-audio-frequency amplifier BC–116.—The circuit diagram of the amplifier is shown on Figure 47. The first tube is a detector tube and has the usual grid leak and condenser in the grid circuit. The detector plate circuit is coupled to the first intermediate frequency amplifier tube by means of iron-core radio-frequency transformer C–56. The detector plate circuit also includes a 0.5 megohm resistance to reduce the plate current to the proper value for a detector tube. The coupling between the third and fourth tubes is by means of an air-core radio-frequency transformer, C–59, which has a fixed condenser across the grid winding forming a highly selective tuned circuit. The fifth and sixth tubes (audio amplifier and detector respectively) are interchanged on the tube shelf from the usual order, so as to make more convenient the filament wiring, which is arranged to provide the proper grid biasing potentials. The fourth tube then has its radio-frequency output connected to the sixth tube which is a detector tube. The detector tube plate circuit includes the primary of an audio-frequency amplifying transformer, with a condenser across the winding to prevent the audio amplifier from howling. The detector tube is connected by means of the transformer to the fifth tube which is used as an audio amplifier. The last tube on the tube shelf is an audio amplifier. Jacks are provided in the plate circuits of the two audio amplifier tubes so that either one or two stages of audio can be used as desired. A 10,000 m. m. f. condenser provides a by-pass from the common plate circuit bus to the filament, reducing the undesired coupling arising from the use of a common plate battery, and leads. The filament circuits are arranged in a series grouping so as to utilize the voltage drop across successive tubes to provide suitable negative grid biasing voltage for the amplifier tubes.

CIRCUIT DIAGRAM
DYNAMOTOR UNIT TYPE BD-46

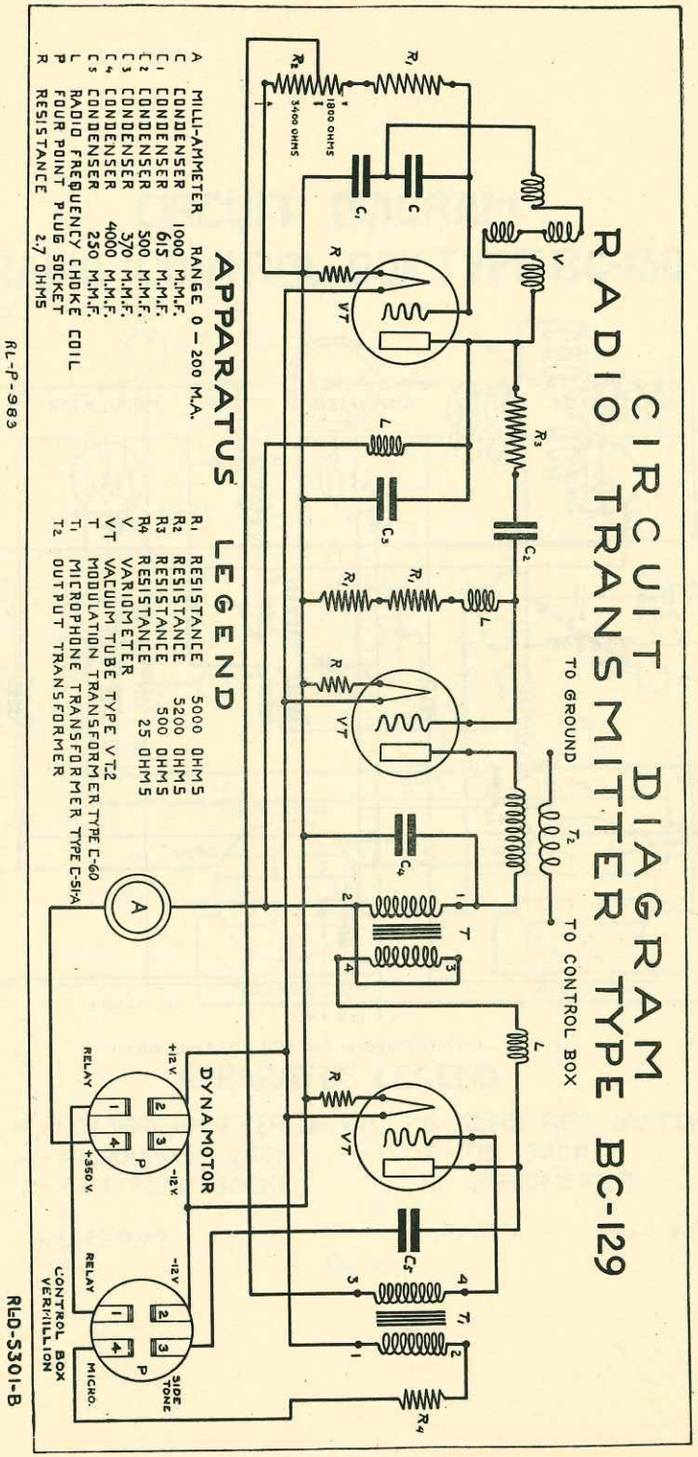


APPARATUS LEGEND

C - 1 MF. CONDENSERS
DM - DYNAMOTOR TYPE - DM-1
P - 4PT. PLUG SOCKET
R - RELAY

FIG. 1

CIRCUIT DIAGRAM
RADIO TRANSMITTER TYPE BC-129



APPARATUS LEGEND

A	MILLI-AMMETER	RANGE 0 – 200 M.A.	
C	CONDENSER	1000 M.M.F.	
C1	CONDENSER	615 M.M.F.	
C2	CONDENSER	500 M.M.F.	
C3	CONDENSER	370 M.M.F.	
C4	CONDENSER	4000 M.M.F.	
C5	CONDENSER	230 M.M.F.	
L	RADIO FREQUENCY CHOKE COIL		
P	FOUR POINT PLUG SOCKET		
R	RESISTANCE	2.7 OHMS	
R1	RESISTANCE	5000 OHMS	
R2	RESISTANCE	5200 OHMS	
R3	RESISTANCE	500 OHMS	
R4	RESISTANCE	25 OHMS	
V	VARIOMETER		
VT	VACUUM TUBE TYPE V-T2		
T	MODULATION TRANSFORMER TYPE C-60		
T1	MICROPHONE TRANSFORMER TYPE C-51A		
T2	OUTPUT TRANSFORMER		

RL-P-983

FIG. 2

RLD-5301-B

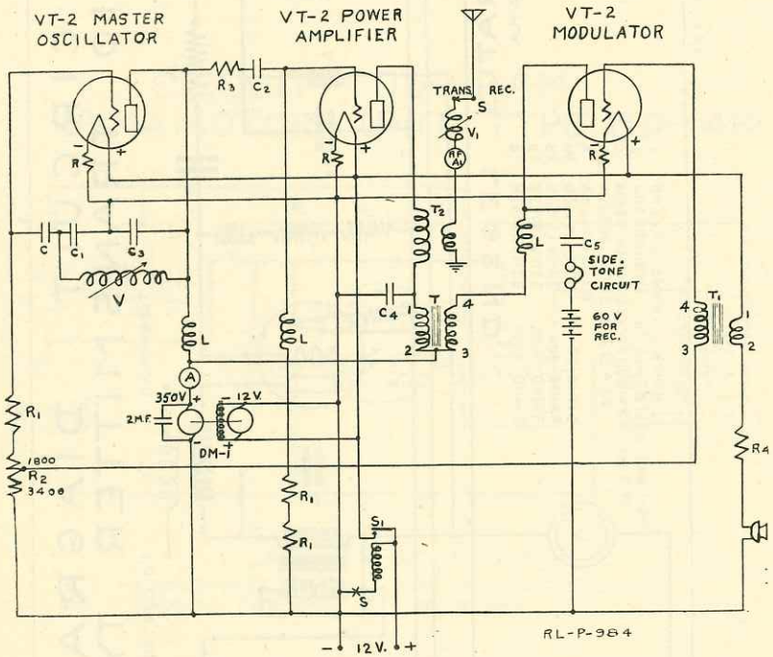
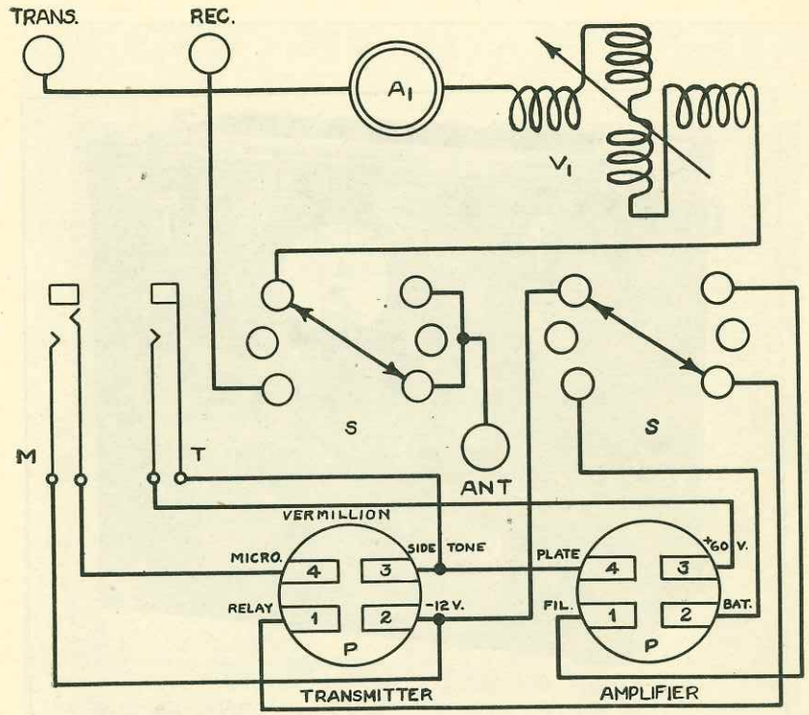


FIG. 3.—Circuit diagram for SCR 133 transmitter

CIRCUIT DIAGRAM
RADIO CONTROL BOX TYPE BC-130



APPARATUS LEGEND

A1 - HOT WIRE AMMETER 0-1.5A
M - MICROPHONE JACK
P - 4 PT. PLUG SOCKET
S - SEND-REC. SWITCH
T - TEL JACK
V1 - VARIOMETER

RL-P-985

RL-D 5331-A

FIG. 4

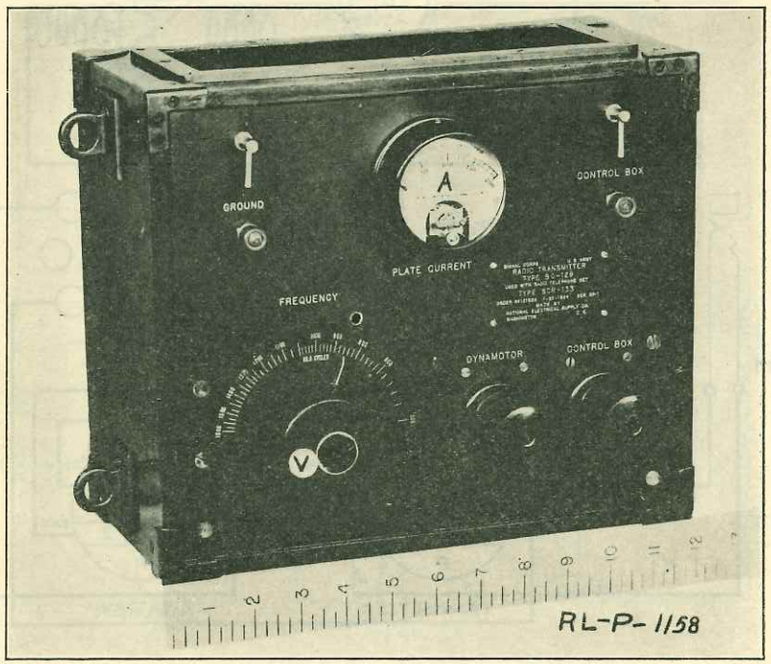


FIG. 5.—Set box, BC 129. Front view

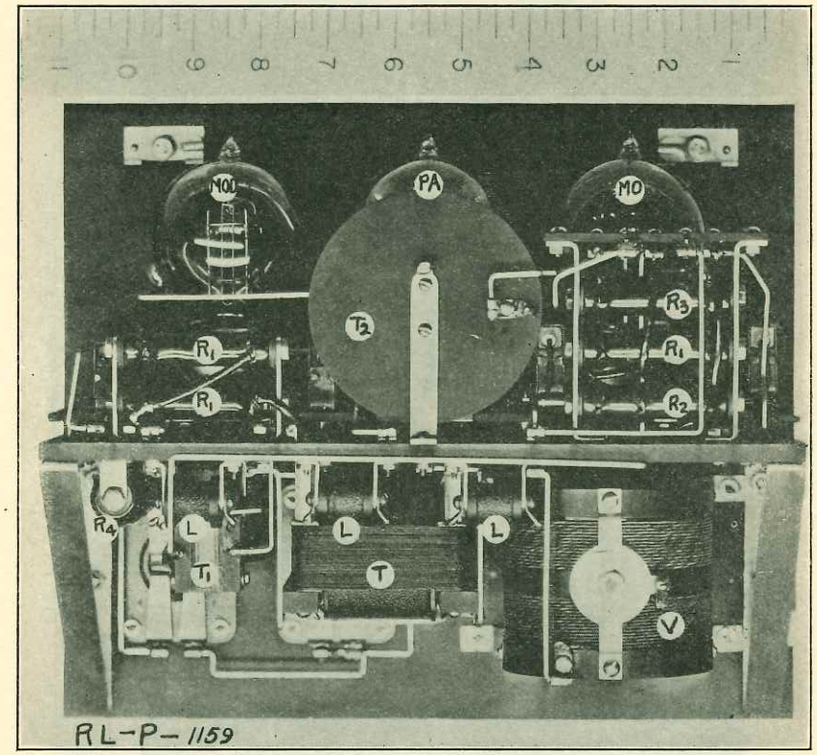


FIG. 6.—Set box, BC 129. Rear view

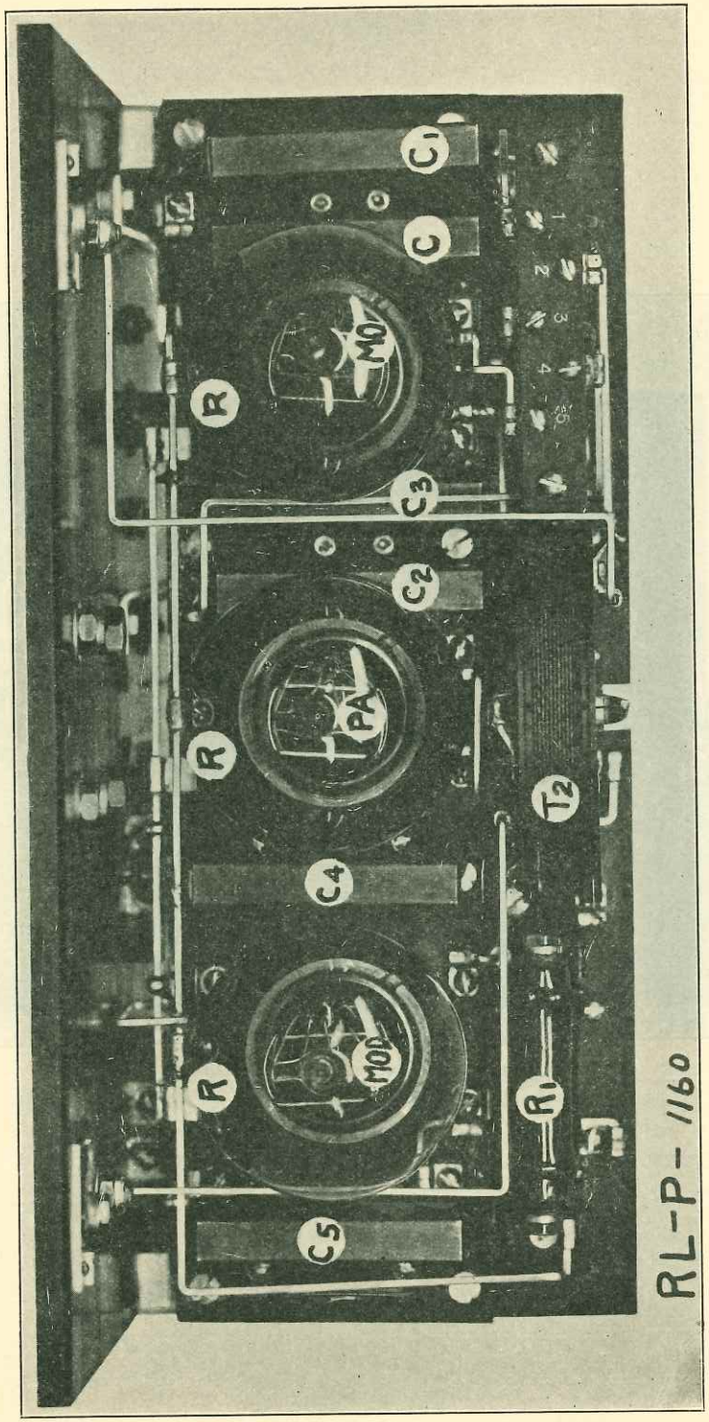


FIG. 7.—Top inside view of set box BC 129

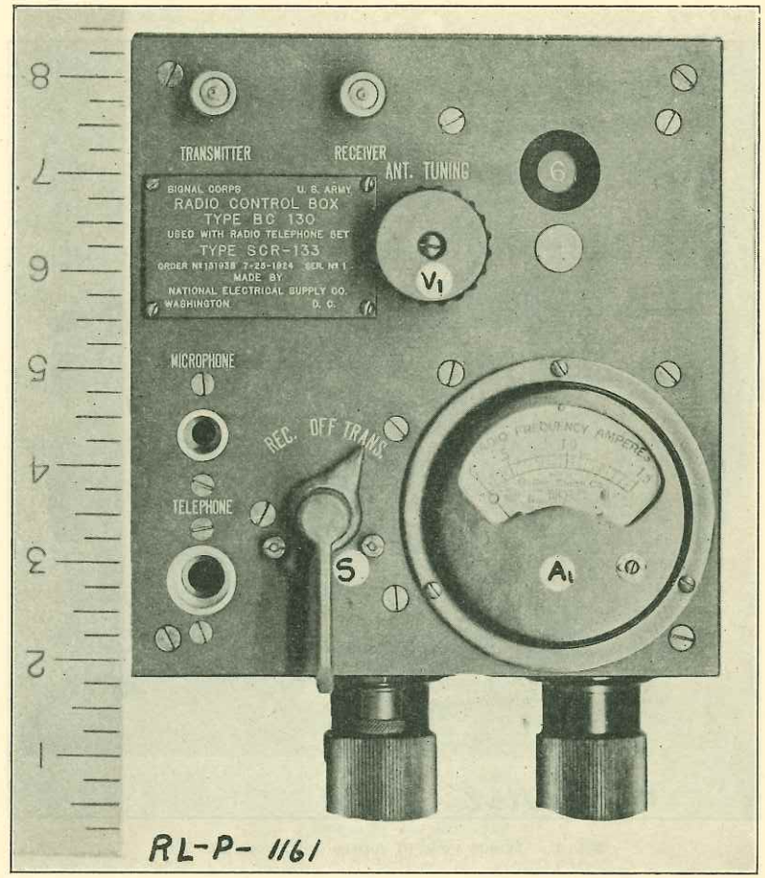


FIG. 8.—Front view of control box, type BC 130

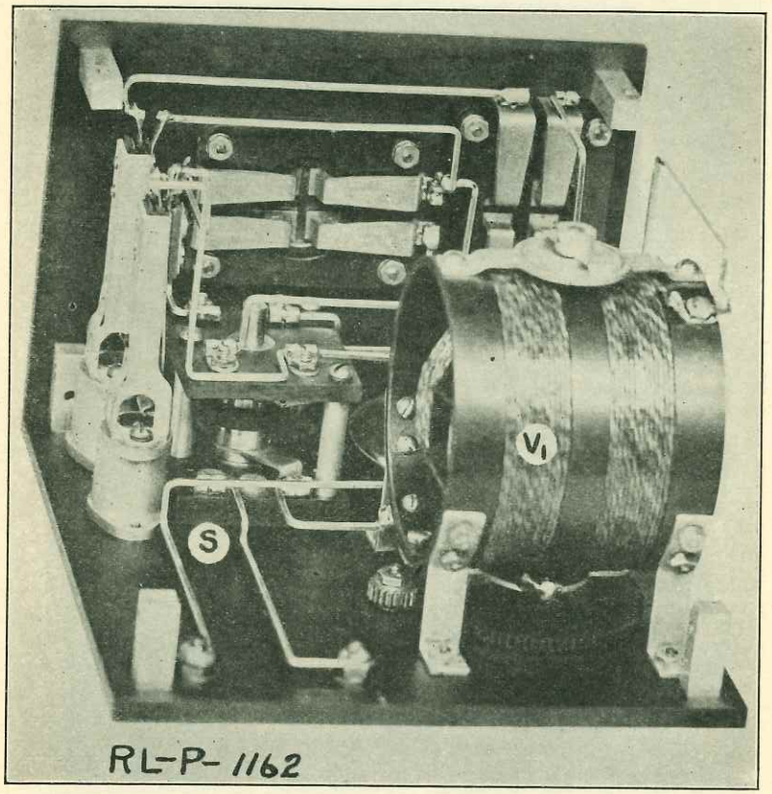
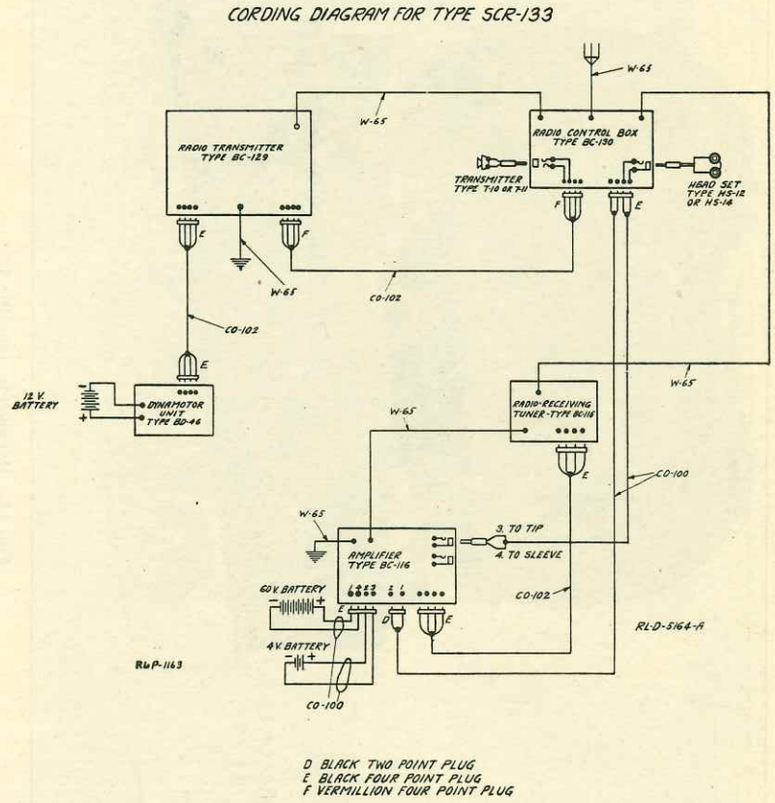


FIG. 9.—Inside view of control box, type BC 130



D BLACK TWO POINT PLUG
E BLACK FOUR POINT PLUG
F VERMILLION FOUR POINT PLUG

FIG. 10

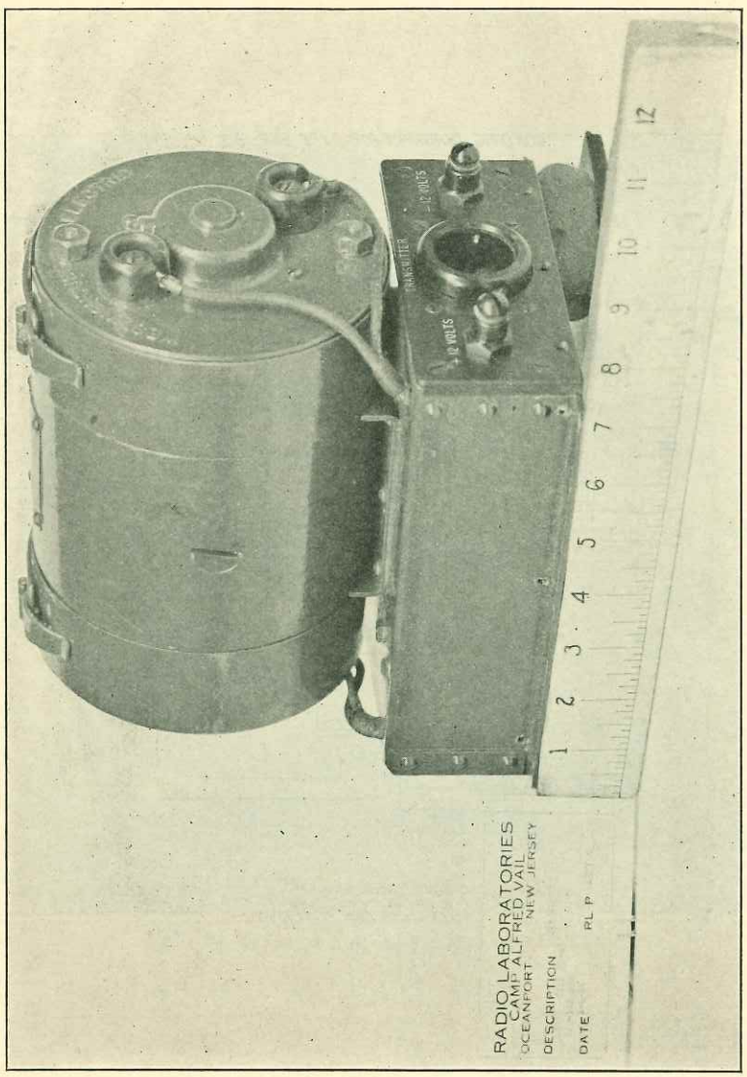


FIG. 11.—Dynamotor, type BD 46

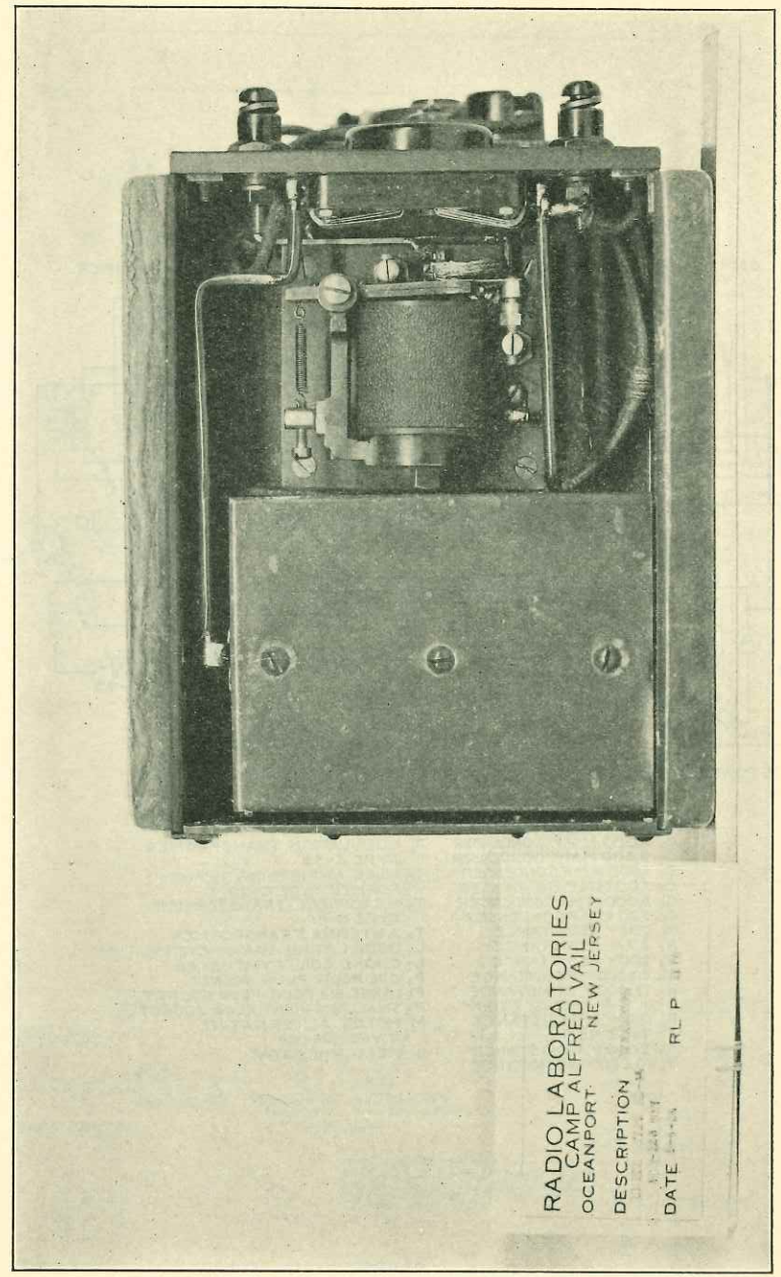
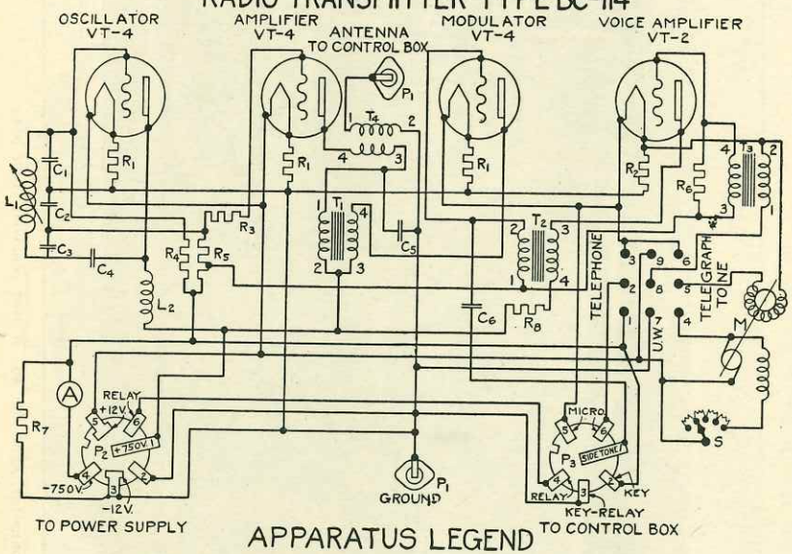


FIG. 12.—Dynamotor, type BD 46. Cover removed from base

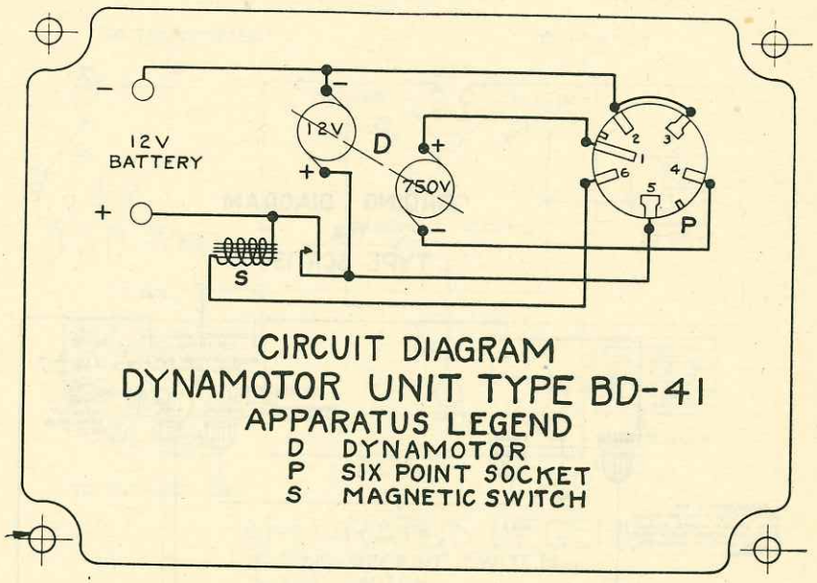
CIRCUIT DIAGRAM
RADIO TRANSMITTER TYPE BC-114



APPARATUS LEGEND

A D.C. MILLIAMETER 0 TO 500 MILLIAMPERES
C_1 4,000 M.M.F. CONDENSER
C_2 2,500 M.M.F. CONDENSER
C_3 1,500 M.M.F. CONDENSER
C_4 500 M.M.F. CONDENSER
C_5 5,000 M.M.F. CONDENSER
C_6 500 M.M.F. CONDENSER
R_1 0.36 ω RESISTANCE
R_2 2.7 ω RESISTANCE
R_3 500 ω RESISTANCE
R_4 20,000 ω RESISTANCE
R_5 15,000 ω RESISTANCE TAPPED AT 2500 ω
R_6 0.5 MEG. RESISTANCE TYPE RS-1
R_7 5,000 ω RESISTANCE
R_8 10,000 ω RESISTANCE
1,2,3,4,5,6,7,8 & 9 MODULATION SWITCH
T_1 MODULATION TRANSFORMER TYPE C-55
T_2 VOICE AMPLIFYING TRANSFORMER TYPE C-50
T_3 MICROPHONE TRANSFORMER TYPE C-51
T_4 ANTENNA TRANSFORMER
L_1 OSCILLATING VARIOMETER
L_2 CHOKE COIL TYPE C-58
P_1 ONE POINT PLUG SOCKET
P_2 LARGE SIX POINT PLUG SOCKET
P_3 SMALL SIX POINT PLUG SOCKET
M MOTOR ALTERNATOR TYPE GN-33
S FIELD RHEOSTAT

FIG. 14



CIRCUIT DIAGRAM
DYNAMOTOR UNIT TYPE BD-41
APPARATUS LEGEND

D DYNAMOTOR
P SIX POINT SOCKET
S MAGNETIC SWITCH

FIG. 15

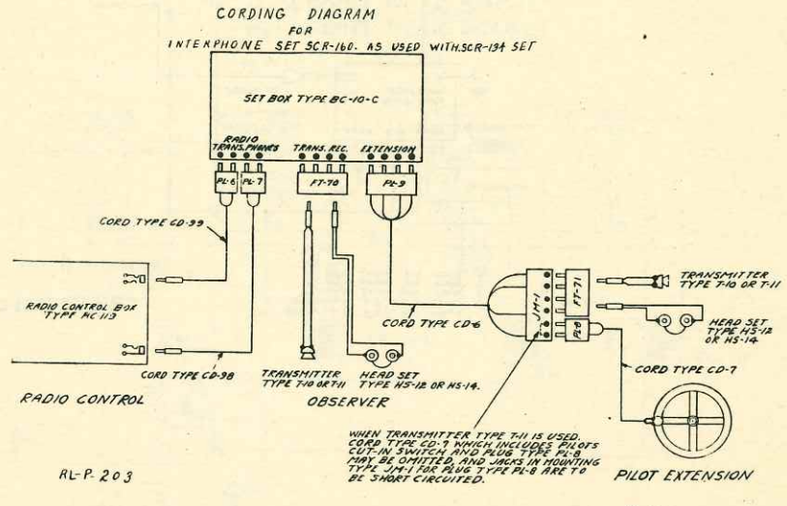

CORDING DIAGRAM FOR INTERPHONE SET SCR-160. AS USED WITH SCR-134 SET
SET BOX TYPE BC-10-C
RADIO TRANS. PHONES
TRANS. REC.
EXTENSION
PL-6
PL-7
PT-70
PL-9
CORD TYPE CD-99
RADIO CONTROL BOX TYPE MC 113
CORD TYPE CD-98
TRANSMITTER TYPE T-10 OR T-11
HEAD SET TYPE HS-12 OR HS-14.
CORD TYPE CD-6
JM-1
PT-71
P18
TRANSMITTER TYPE T-10 OR T-11
HEAD SET TYPE HS-12 OR HS-14
CORD TYPE CD-7
RADIO CONTROL
OBSERVER
WHEN TRANSMITTER TYPE T-11 IS USED, CORD TYPE CD-7 WHICH INCLUDES PILOTS CUT-IN SWITCH AND PLUG TYPE PL-9 MAY BE OMITTED, AND JACKS IN MOUNTING TYPE JM-1 FOR PLUG TYPE PL-8 ARE TO BE SHORT CIRCUITED.
PILOT EXTENSION
RL-P. 203
RL-D-5127-B

FIG. 16

CORDING DIAGRAM FOR TYPE SCR-134

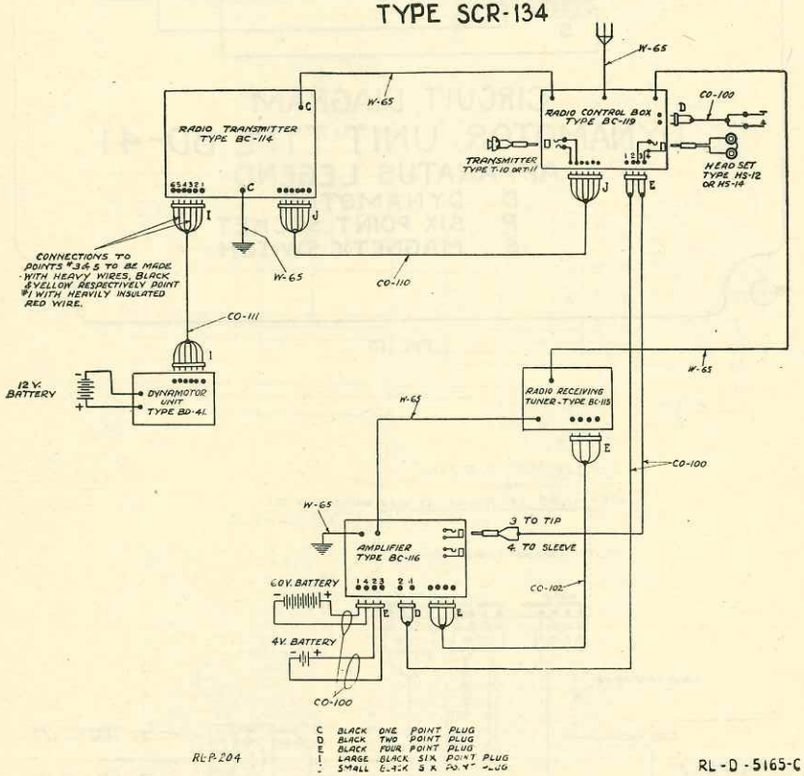
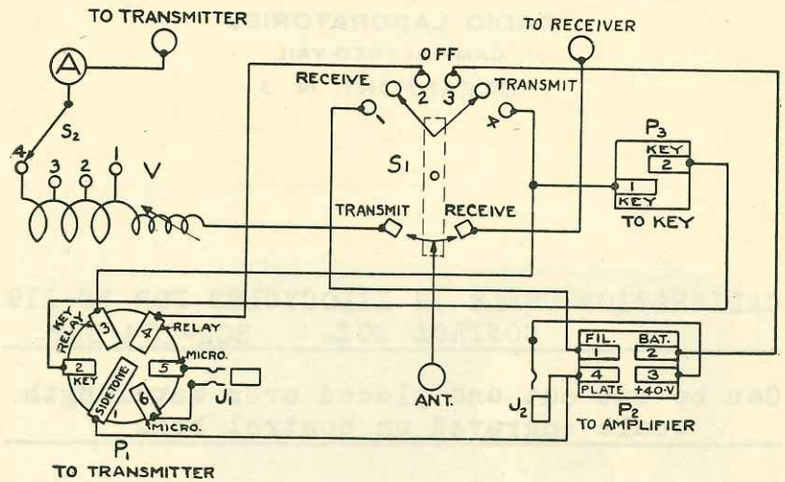

RADIO TRANSMITTER TYPE BC-114
RADIO CONTROL BOX TYPE BC-119
TRANSMITTER TYPE T-10 OR T-11
HEAD SET TYPE HS-12 OR HS-16
CONNECTIONS TO POINTS #3 & 5 TO BE MADE WITH HEAVY WIRES, BLACK & YELLOW RESPECTIVELY POINT #1 WITH HEAVILY INSULATED RED WIRE.
12 V. BATTERY
DYNAMOTOR UNIT TYPE BD-41
RADIO RECEIVING TUNER TYPE BC-113
AMPLIFIER TYPE BC-116
3 TO TIP
4 TO SLEEVE
60 V. BATTERY
4 V. BATTERY
W-65
CO-100
CO-110
CO-111
CO-102
C BLACK ONE POINT PLUG
D BLACK TWO POINT PLUG
E BLACK FOUR POINT PLUG
I LARGE BLACK SIX POINT PLUG
J SMALL BLACK 3 X POINT PLUG
RLP-204
RL-D-5165-C

FIG. 17

CIRCUIT DIAGRAM RADIO CONTROL BOX TYPE BC-119



APPARATUS LEGEND

S_1 - SEND-RECEIVE SWITCH
S_2 - TAP SWITCH
A - THERMO AMMETER
V - VARIOMETER
J_1 - MICROPHONE JACK
J_2 - TELEPHONE JACK
P_1 - 6 POINT PLUG SOCKET
P_2 - 4 POINT PLUG SOCKET
P_3 - 2 POINT PLUG SOCKET

FIG. 18

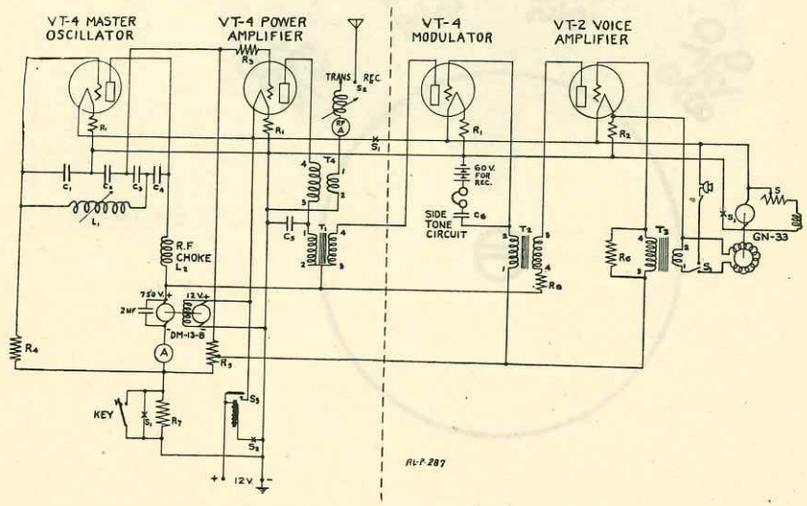


FIG. 19.—Schematic circuit diagram, BC 114

SIGNAL CORPS, U. S. ARMY
RADIO LABORATORIES
CAMP ALFRED VAIL
OCEANPORT, N. J.

CALIBRATION SCALE IN KILOCYCLES FOR BC-119 CONTROL BOX. - SCR-134 SET.

Can be cut out and placed over wavelength scale engraved on control box.

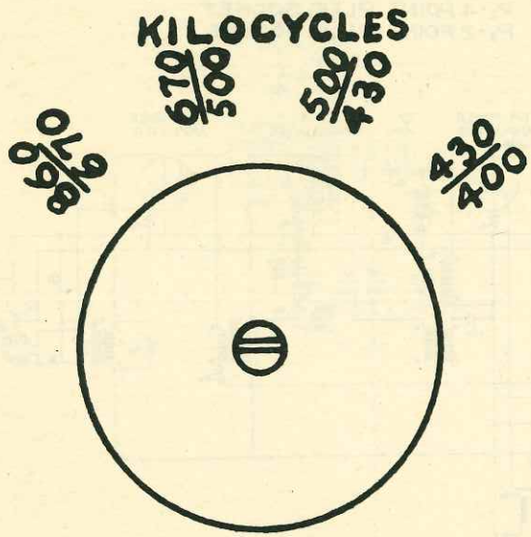


FIG. 20

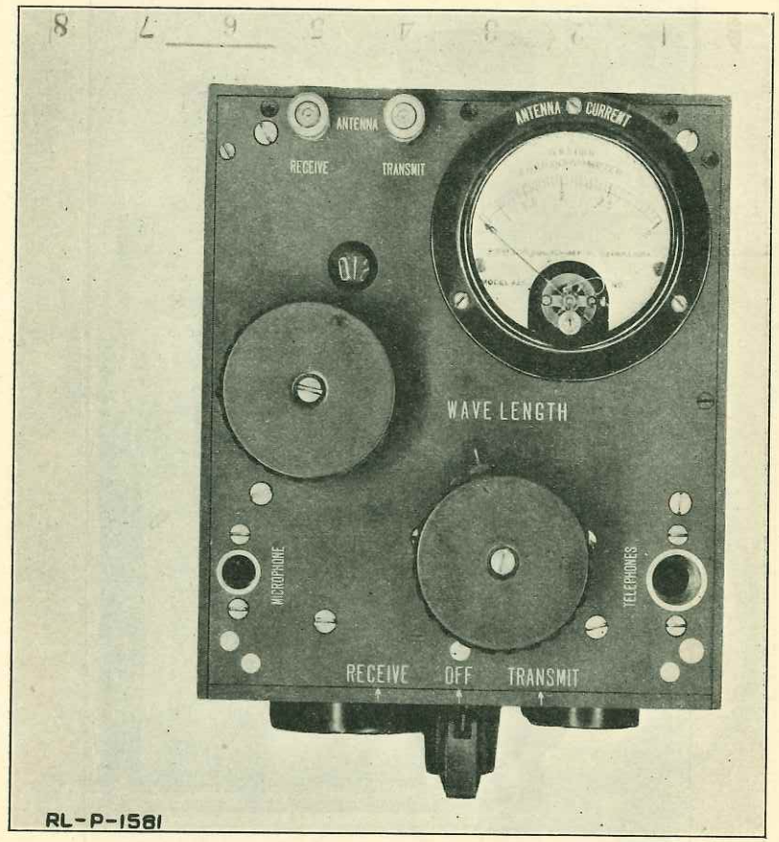


FIG. 21.—Control box, type BC 119. Front view

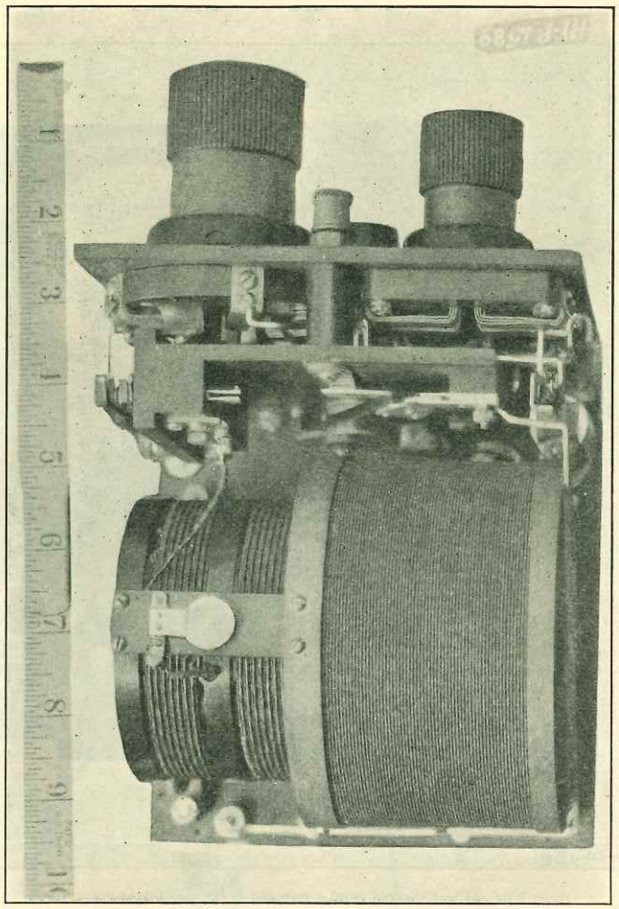


FIG. 22.—Control box, type BC 119. Inside view

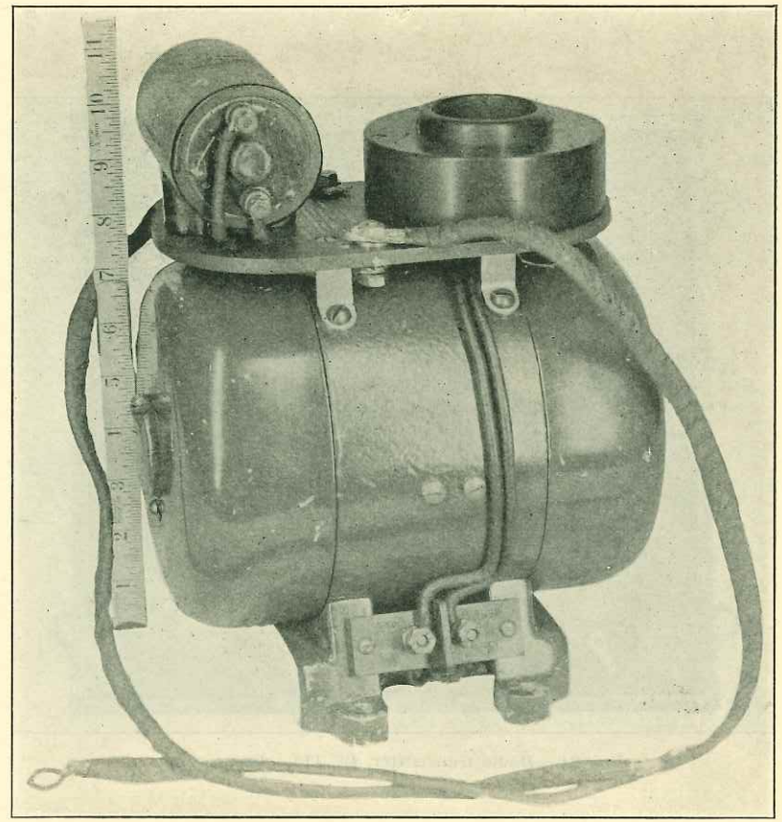


FIG. 23.—Dynamotor unit, type BD 41

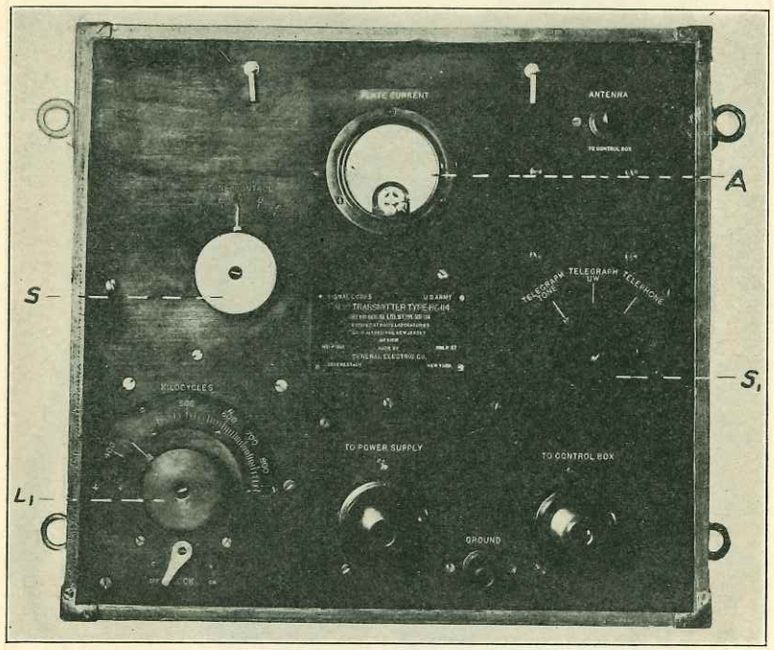


FIG. 24.—Radio transmitter, BC 114. Front view

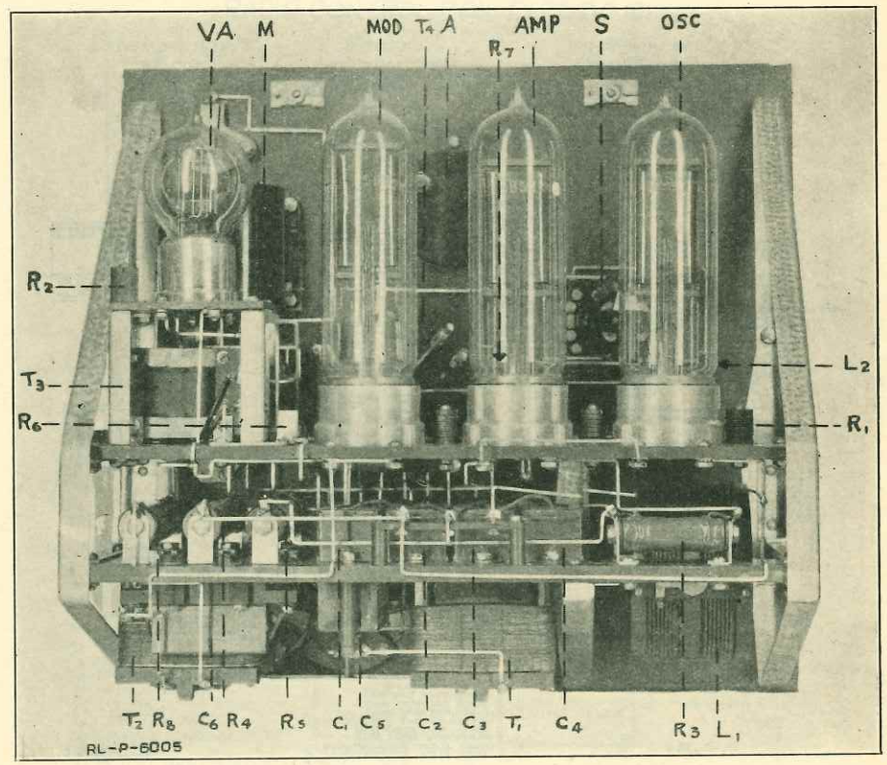
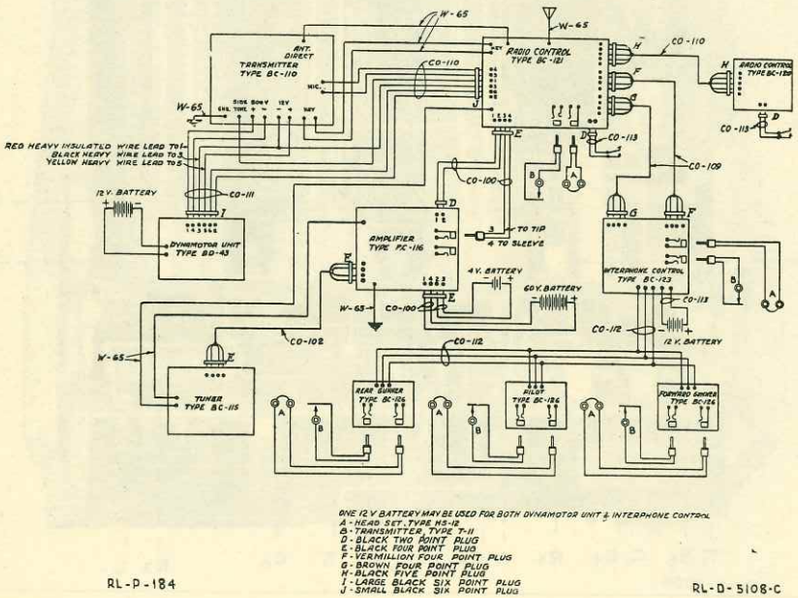


FIG. 25.—Radio transmitter, type BC 114. Inside view

CORDING DIAGRAM FOR TYPE SCR-135 & SCR-155

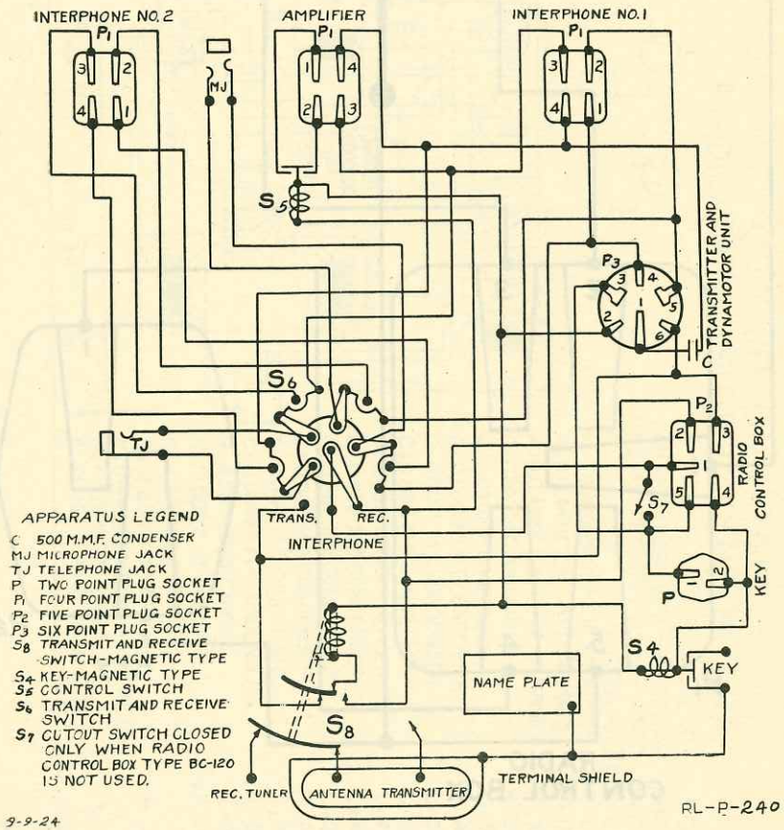


ONE 12 V BATTERY MAY BE USED FOR BOTH DYNAMOTOR UNIT & INTERPHONE CONTROL
A - HEAD SET, TYPE HS-12
B - TRANSMITTER, TYPE T-11
D - BLACK TWO POINT PLUG
E - BLACK FOUR POINT PLUG
F - VERMILLION FOUR POINT PLUG
G - BROWN FOUR POINT PLUG
H - BLACK FIVE POINT PLUG
I - LARGE BLACK SIX POINT PLUG
J - SMALL BLACK SIX POINT PLUG

RL-P-184 RL-D-5108-C

FIG. 26

CIRCUIT DIAGRAM RADIO CONTROL BOX TYPE BC-121



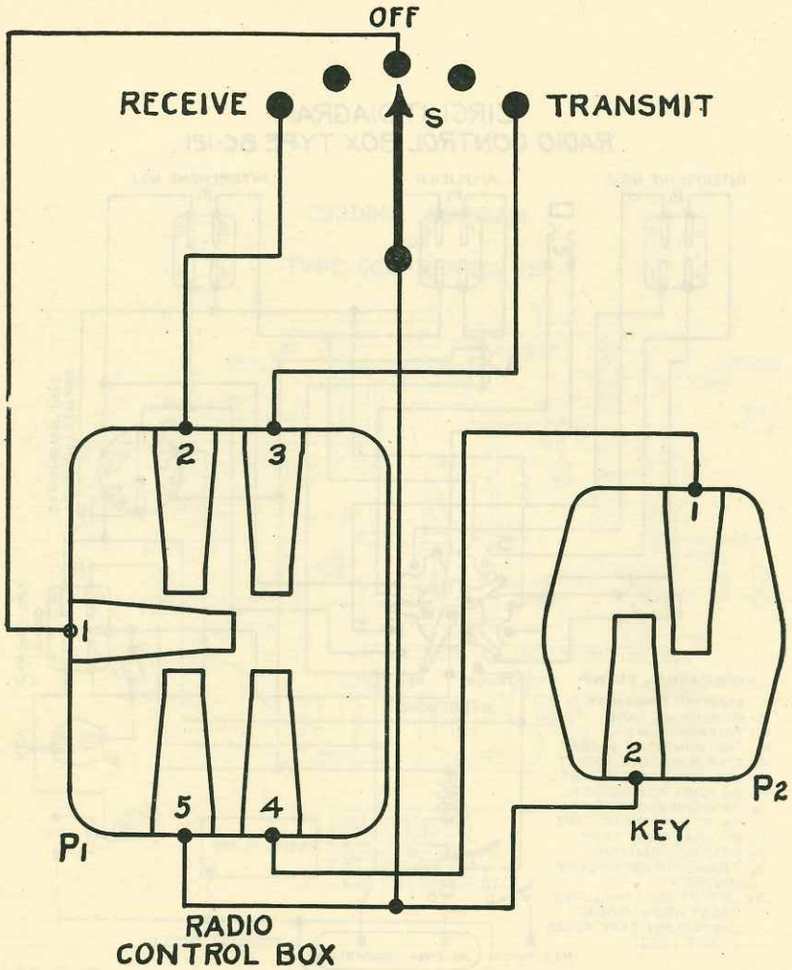
APPARATUS LEGEND

C 500 M.M.F. CONDENSER
MJ MICROPHONE JACK
TJ TELEPHONE JACK
P TWO POINT PLUG SOCKET
P1 FOUR POINT PLUG SOCKET
P2 FIVE POINT PLUG SOCKET
P3 SIX POINT PLUG SOCKET
S8 TRANSMIT AND RECEIVE SWITCH-MAGNETIC TYPE
S4 KEY-MAGNETIC TYPE
S5 CONTROL SWITCH
S6 TRANSMIT AND RECEIVE SWITCH
S7 CUTOUT SWITCH CLOSED ONLY WHEN RADIO CONTROL BOX TYPE BC-120 IS NOT USED.

9-9-24 RL-P-240

FIG. 27

CIRCUIT DIAGRAM
RADIO CONTROL BOX TYPE BC-120



APPARATUS LEGEND

S - SWITCH
P1 - FIVE POINT PLUG SOCKET
P2 - TWO POINT PLUG SOCKET

RL-P-279

RL-D-5101-B.

FIG. 28

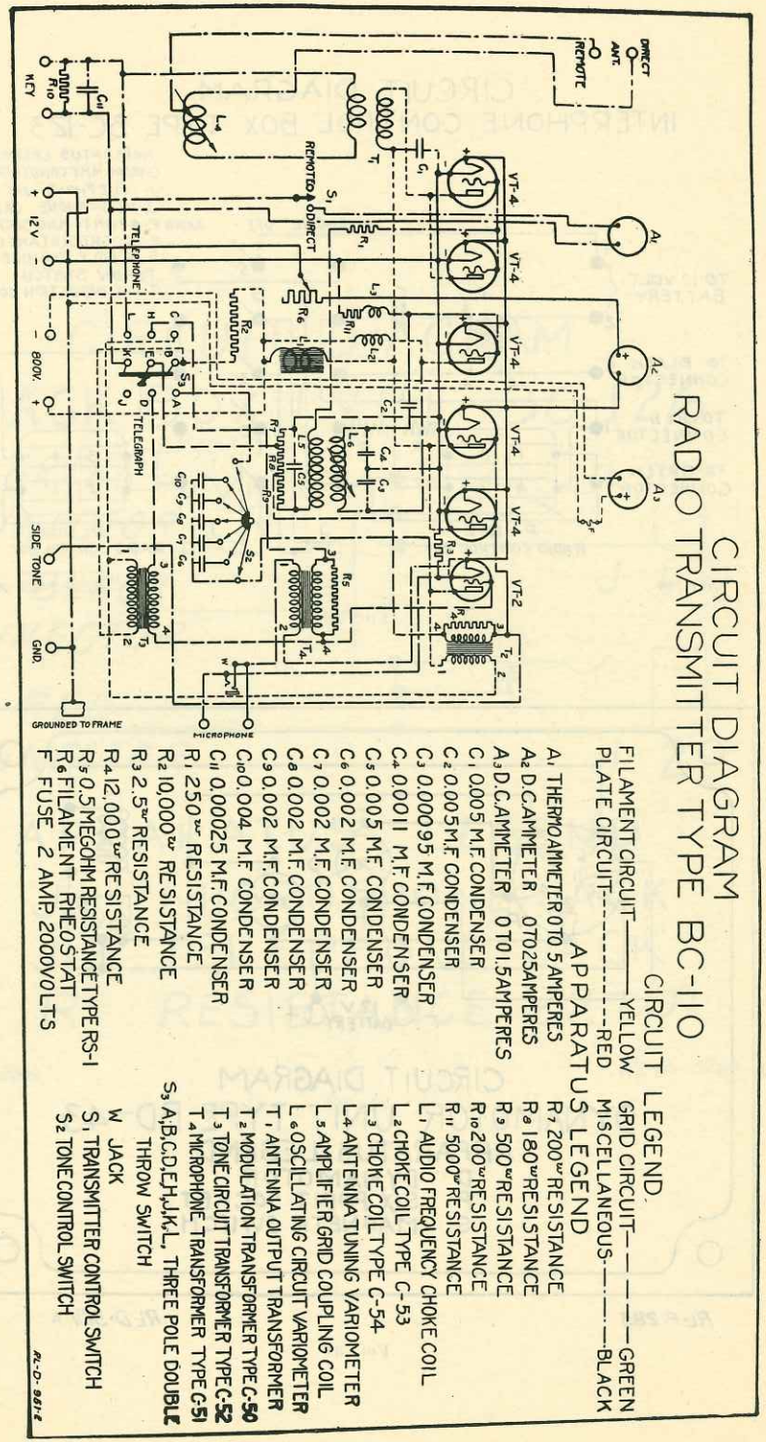


FIG. 29

RL-P-253

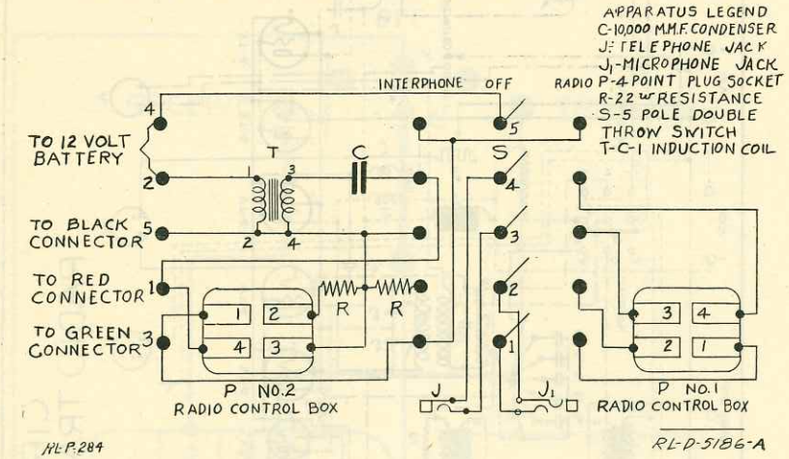


FIG. 30

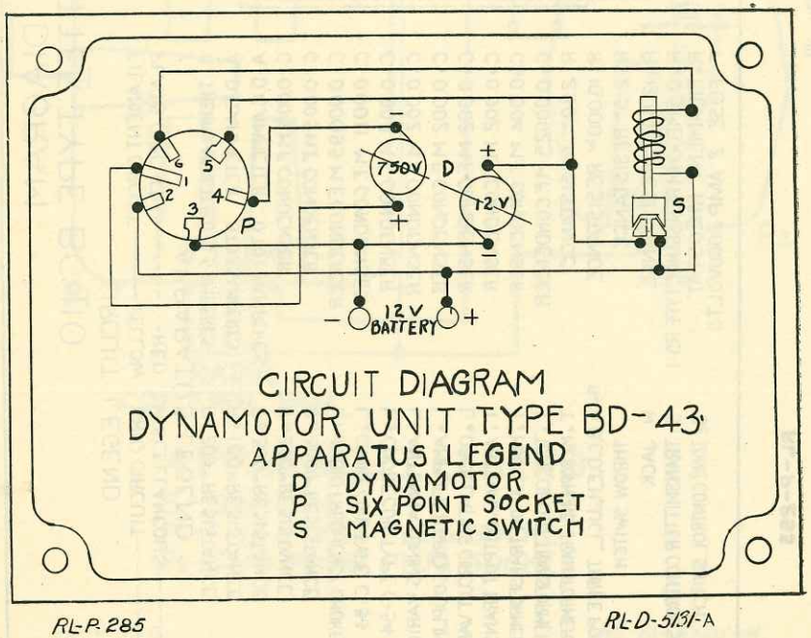


FIG. 31

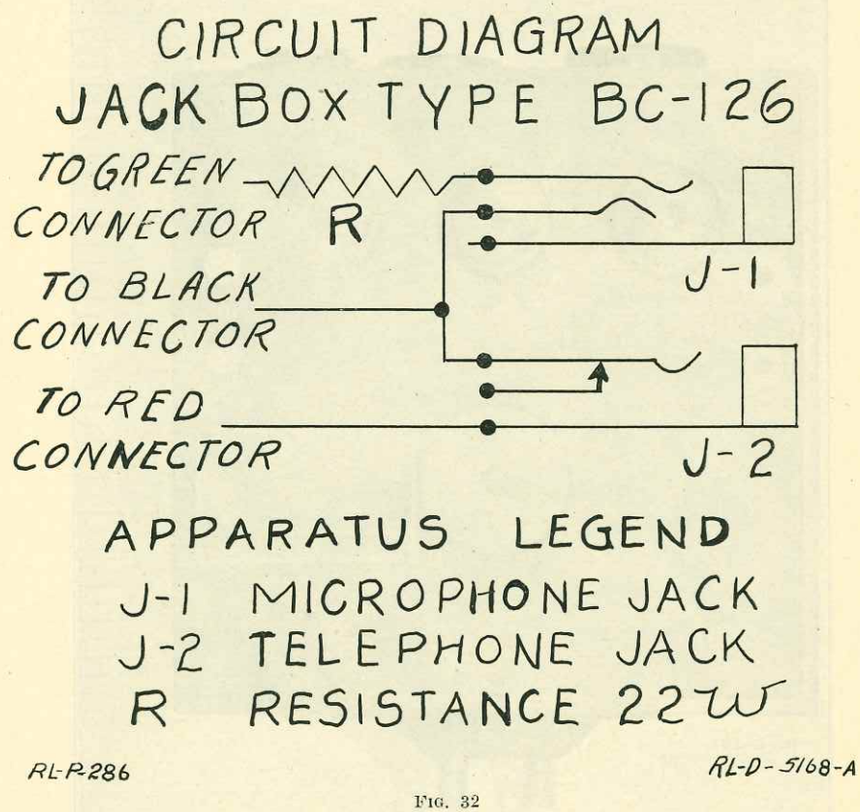


FIG. 32

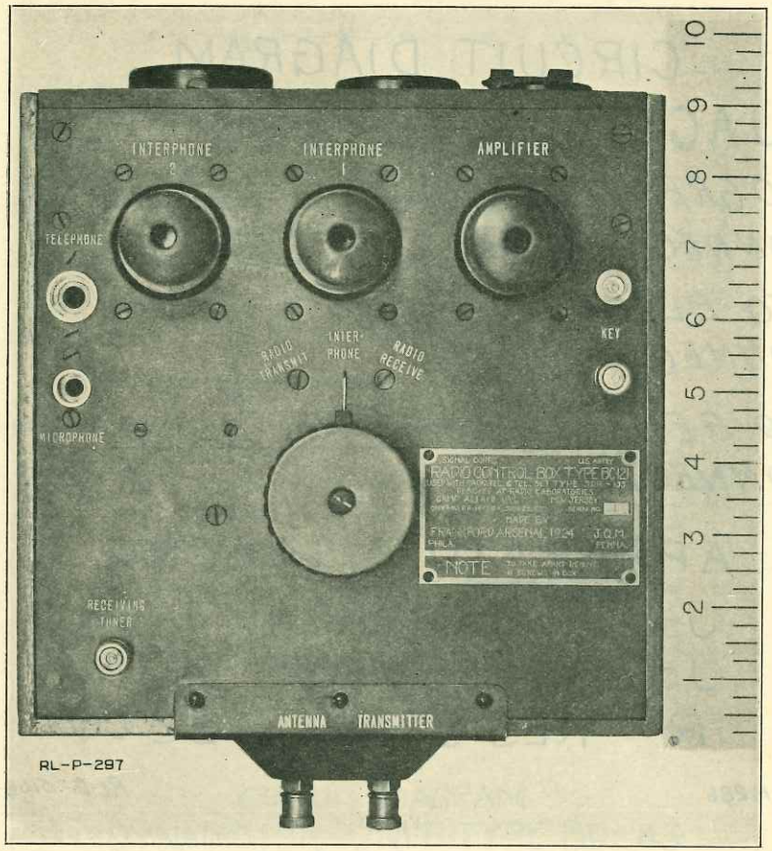


FIG. 33.—Radio control box, BC 121. Front view

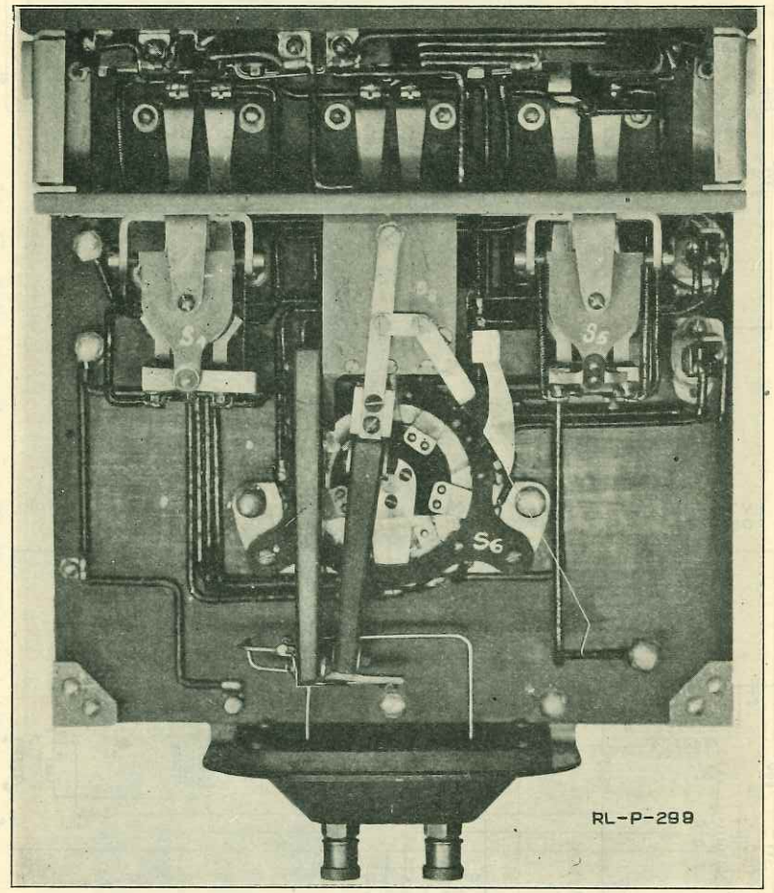


FIG. 34.—Inside view of radio control box BC 121

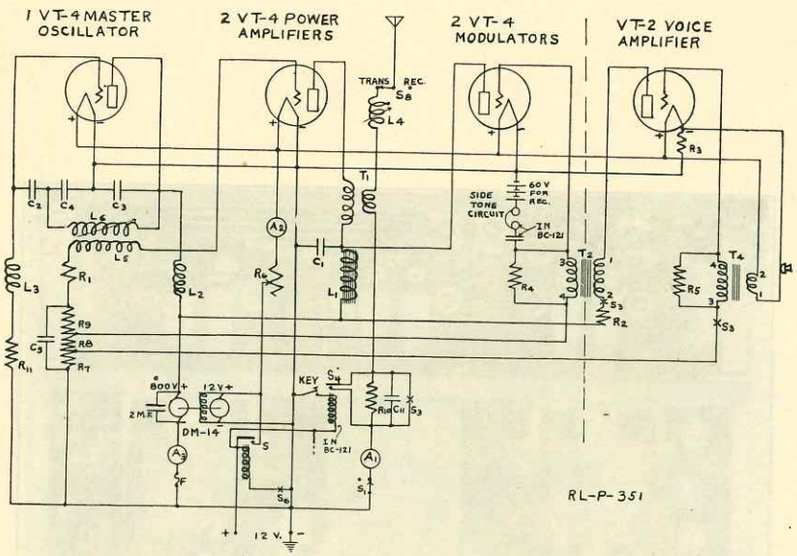


FIG. 35.—Schematic diagram of circuit of radio transmitter, type BC 110

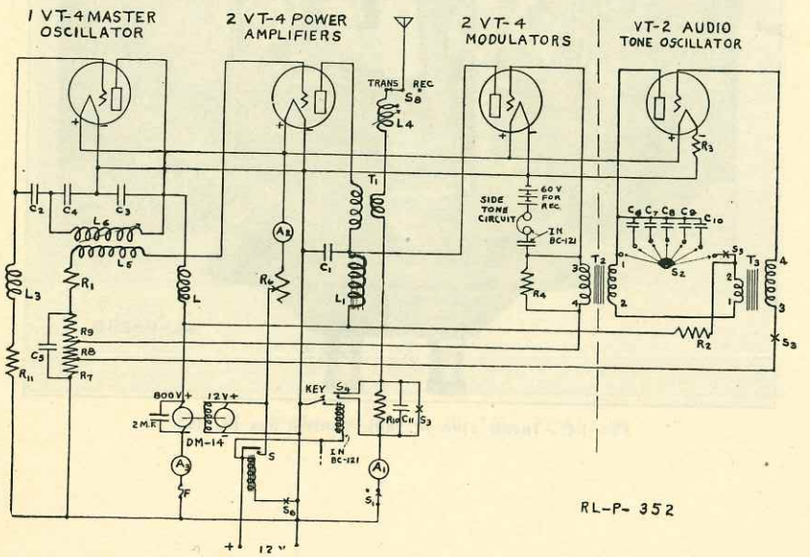


FIG. 36.—Schematic circuit diagram for transmitter BC 110 when adjusted for telegraph operation

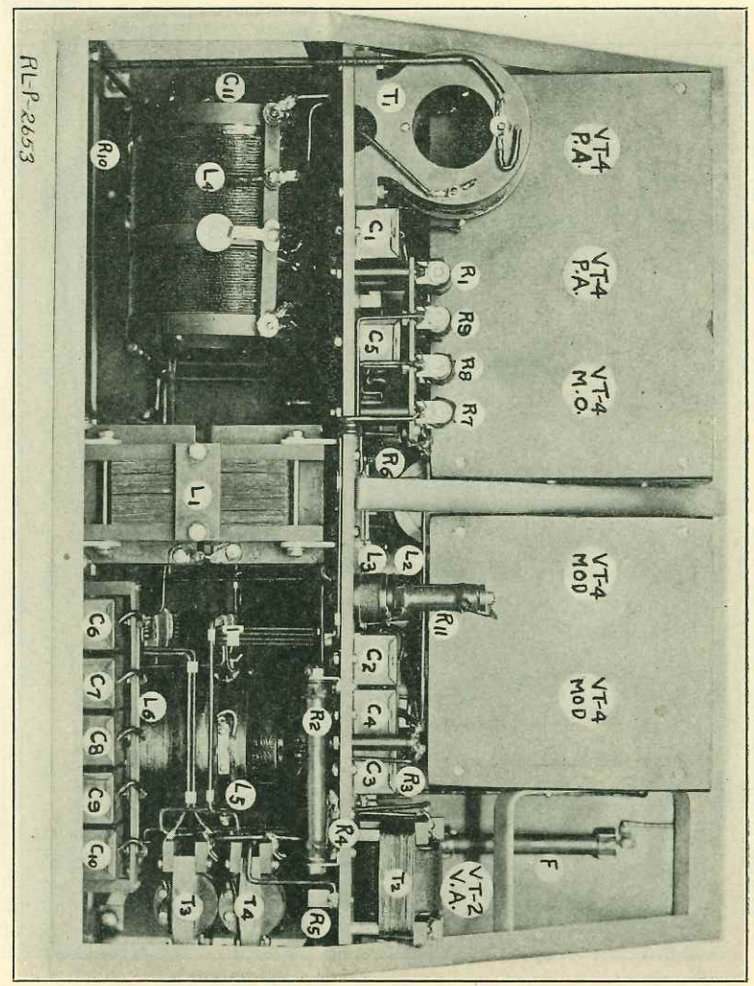


FIG. 37.—Radio transmitter, type BC 110. Rear inside view

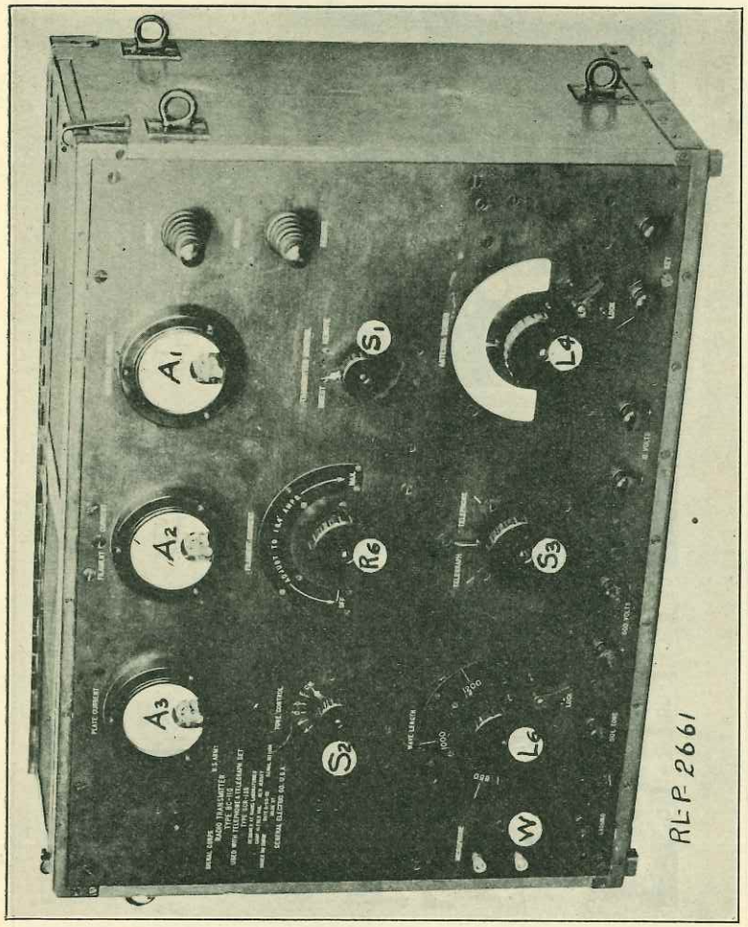


FIG. 38.—Front view, radio transmitter, BC 110

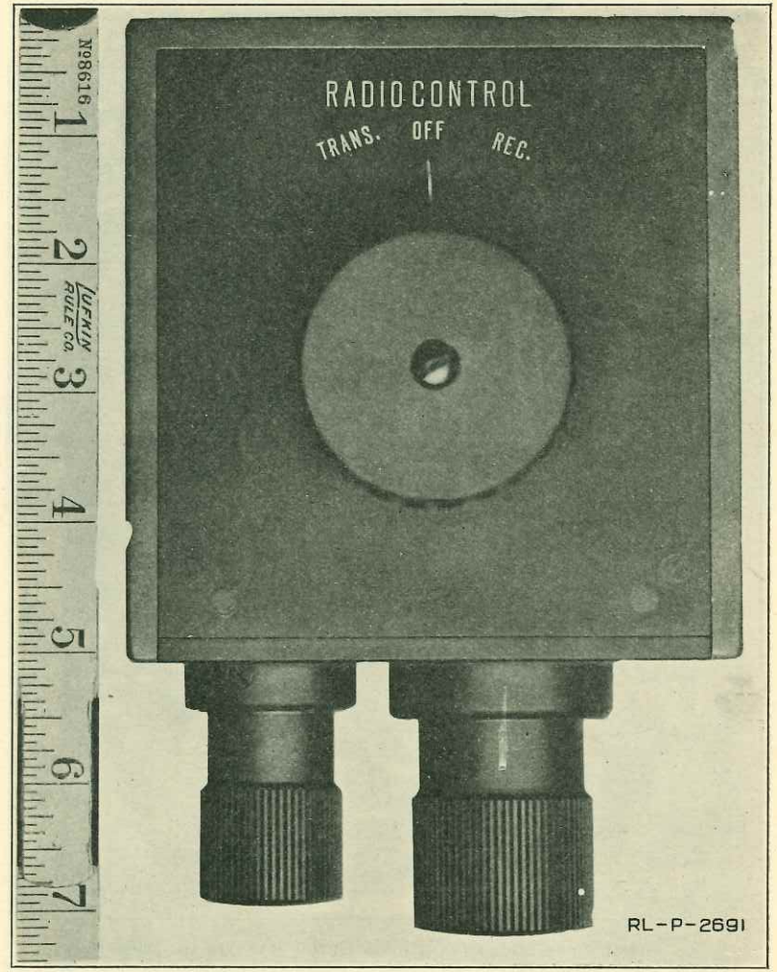


FIG. 39.—Radio control box, type BC 120. Front view

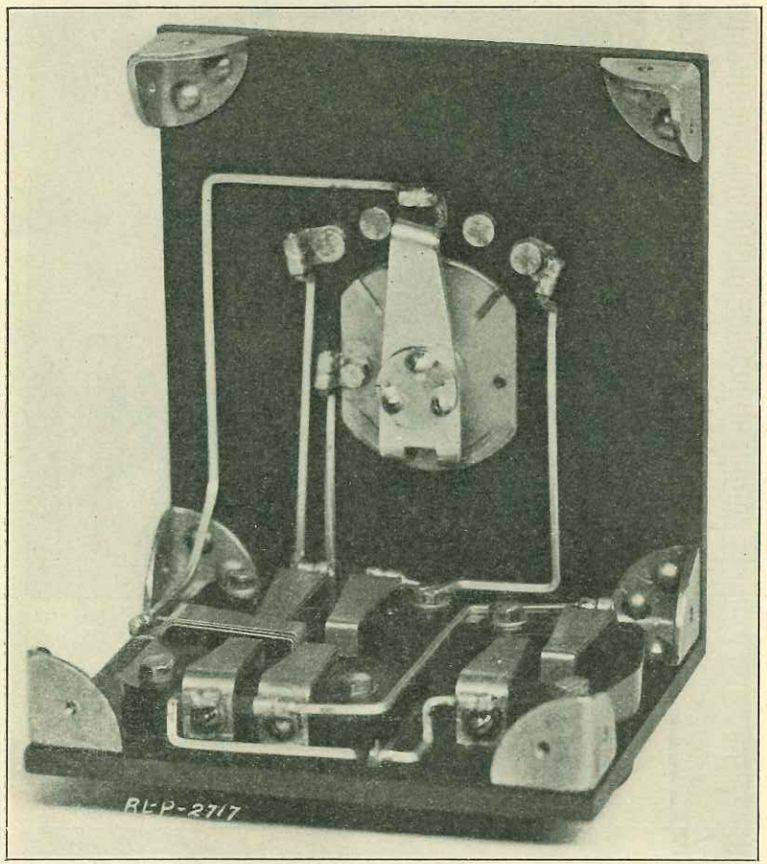


FIG. 40.—Inside view of radio control box, type BC 120

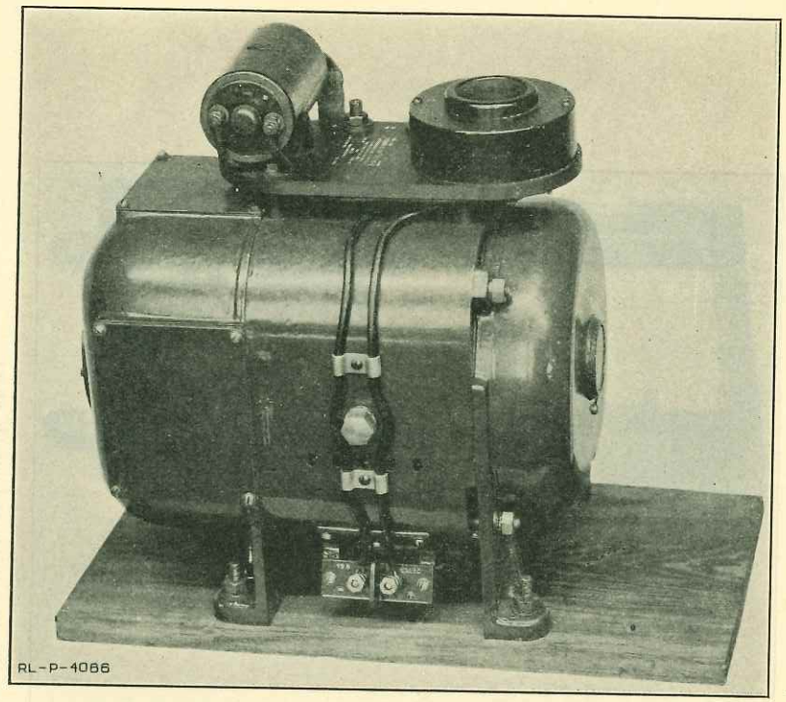


FIG. 41.—Dynamotor, type BD 43

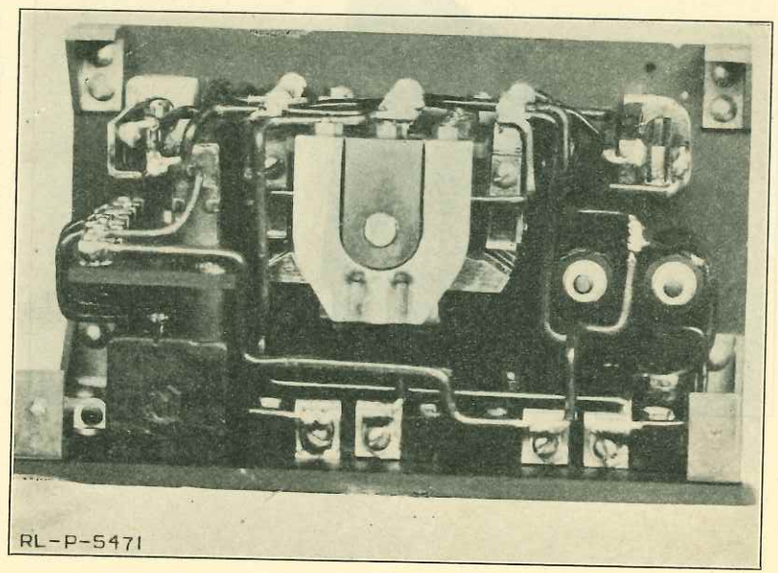


FIG. 42.—Inside view of interfone control box, type BC 123

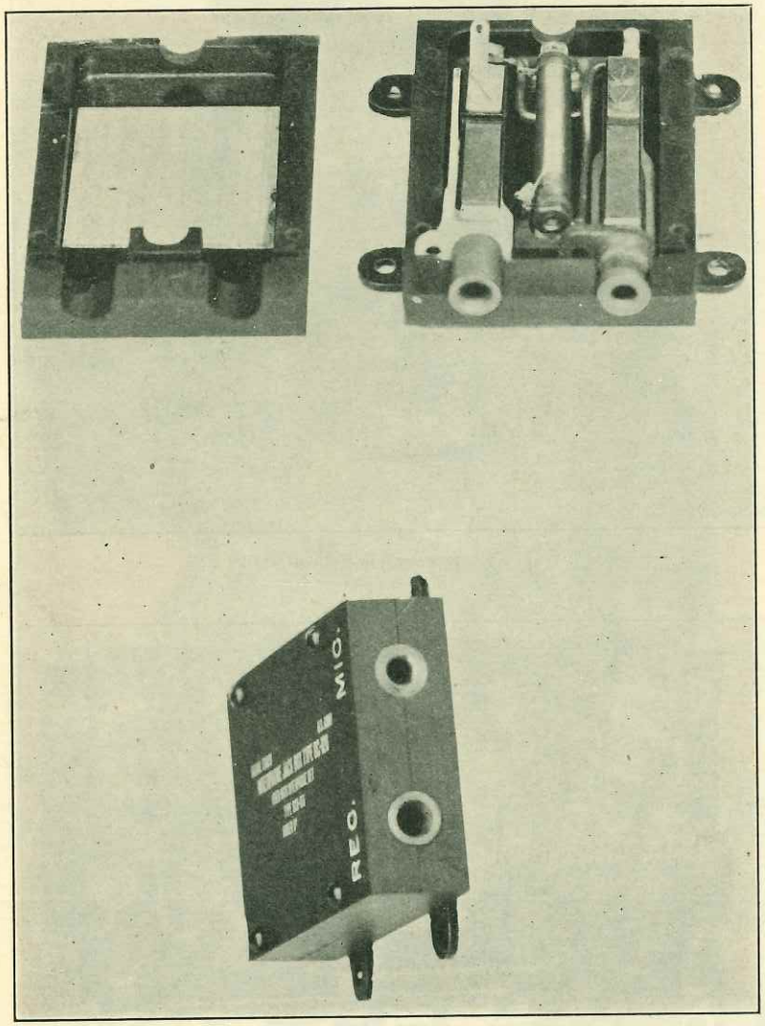


FIG. 43.—Interfone box jack, type BC 12. Inside and outside views

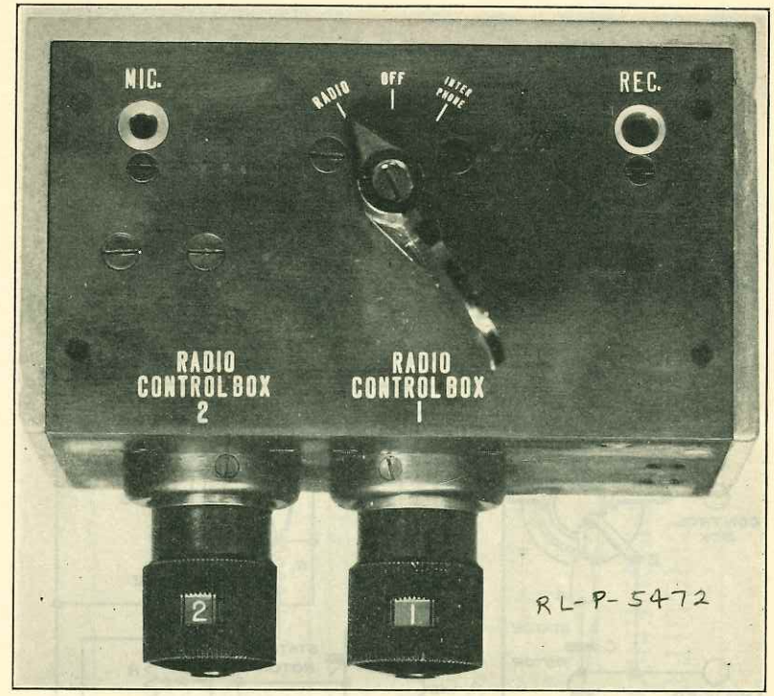


FIG. 44.—Box, interfone control, type BC 123. Front view

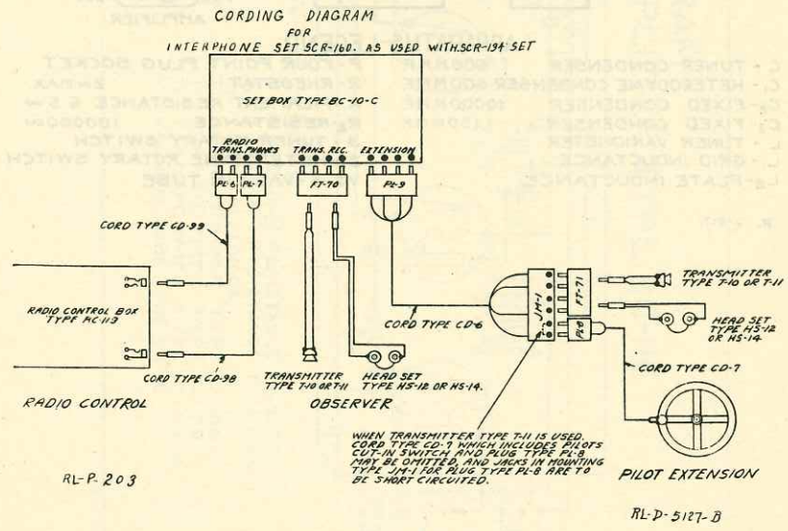
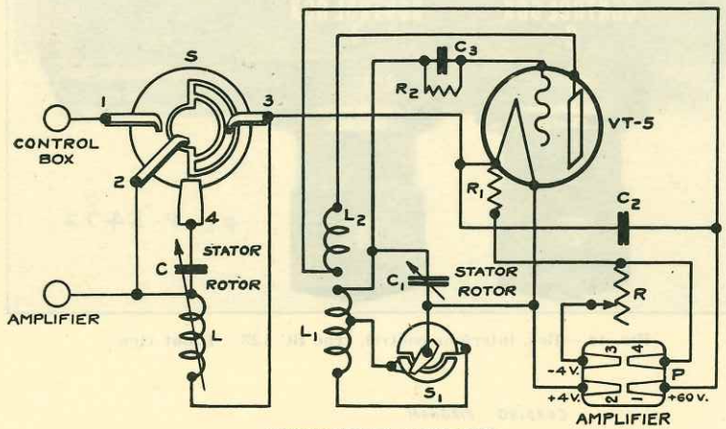


FIG. 45

CIRCUIT DIAGRAM
RADIO RECEIVING TUNER TYPE BC-115



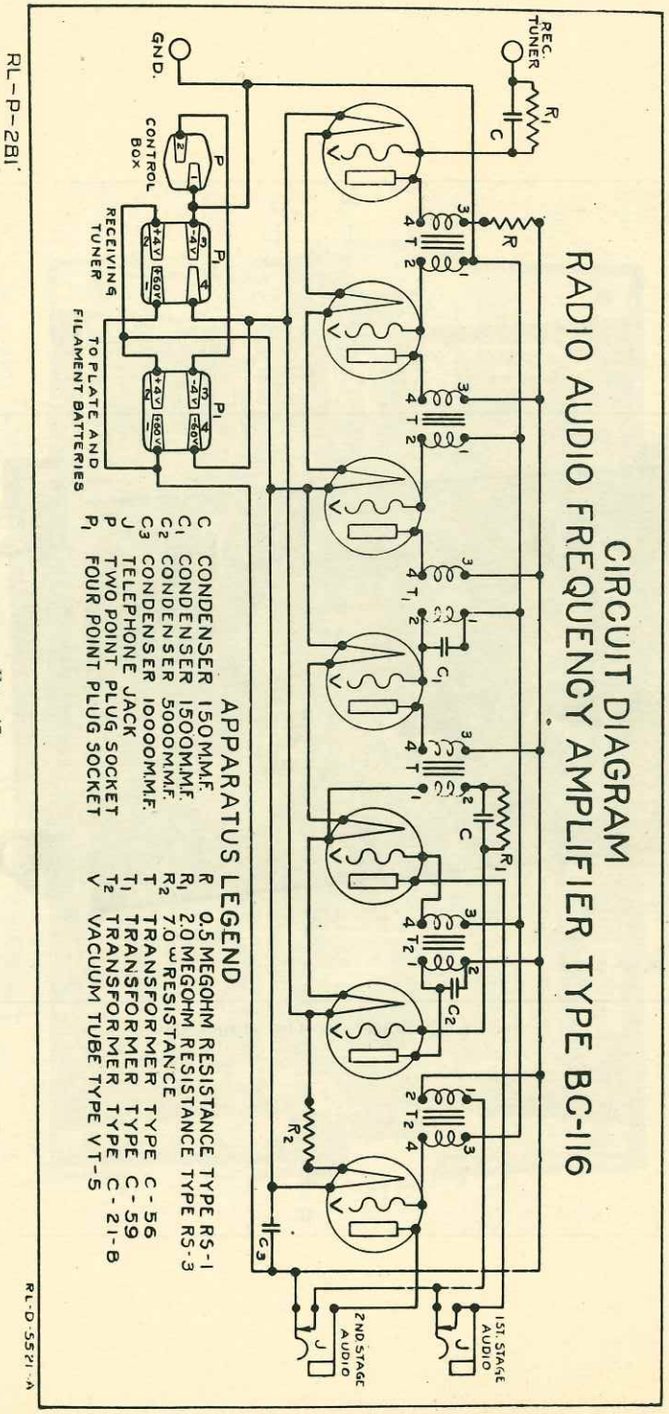
APPARATUS LEGEND

C - TUNER CONDENSER	600 M.M.F.	P - FOUR POINT PLUG SOCKET	
C_1 - HETERODYNE CONDENSER	600 M.M.F.	R - RHEOSTAT	2 ω MAX.
C_2 - FIXED CONDENSER	10000 M.M.F.	R_1 - FILAMENT RESISTANCE	6.5 ω
C_3 - FIXED CONDENSER	150 M.M.F.	R_2 - RESISTANCE	100000 ω
L - TUNER VARIOMETER		S - TUNER ROTARY SWITCH	
L_1 - GRID INDUCTANCE		S_1 - HETERODYNE ROTARY SWITCH	
L_2 - PLATE INDUCTANCE		VT-5 - VACUUM TUBE	

RL-D-5171

FIG. 46

CIRCUIT DIAGRAM
RADIO AUDIO FREQUENCY AMPLIFIER TYPE BC-116



APPARATUS LEGEND

C	CONDENSER	150 M.M.F.	
C_1	CONDENSER	1500 M.M.F.	
C_2	CONDENSER	5000 M.M.F.	
C_3	CONDENSER	10000 M.M.F.	
J	TELEPHONE JACK		
P	TWO POINT PLUG SOCKET		
P_1	FOUR POINT PLUG SOCKET		
R	0.5 MEGOHM RESISTANCE	TYPE RS-1	
R_1	2.0 MEGOHM RESISTANCE	TYPE RS-3	
R_2	7.0 ω RESISTANCE		
T	TRANSFORMER	TYPE C-56	
T_1	TRANSFORMER	TYPE C-59	
T_2	TRANSFORMER	TYPE C-21-B	
V	VACUUM TUBE	TYPE VT-5	

RL-P-281

FIG. 47

RL-D-5521-A

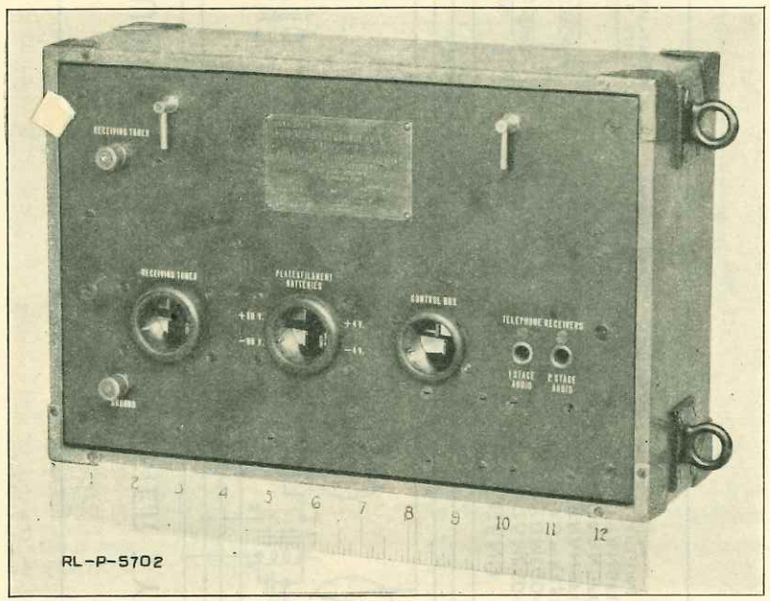


FIG. 48.—Amplifier, BC 116. Front view

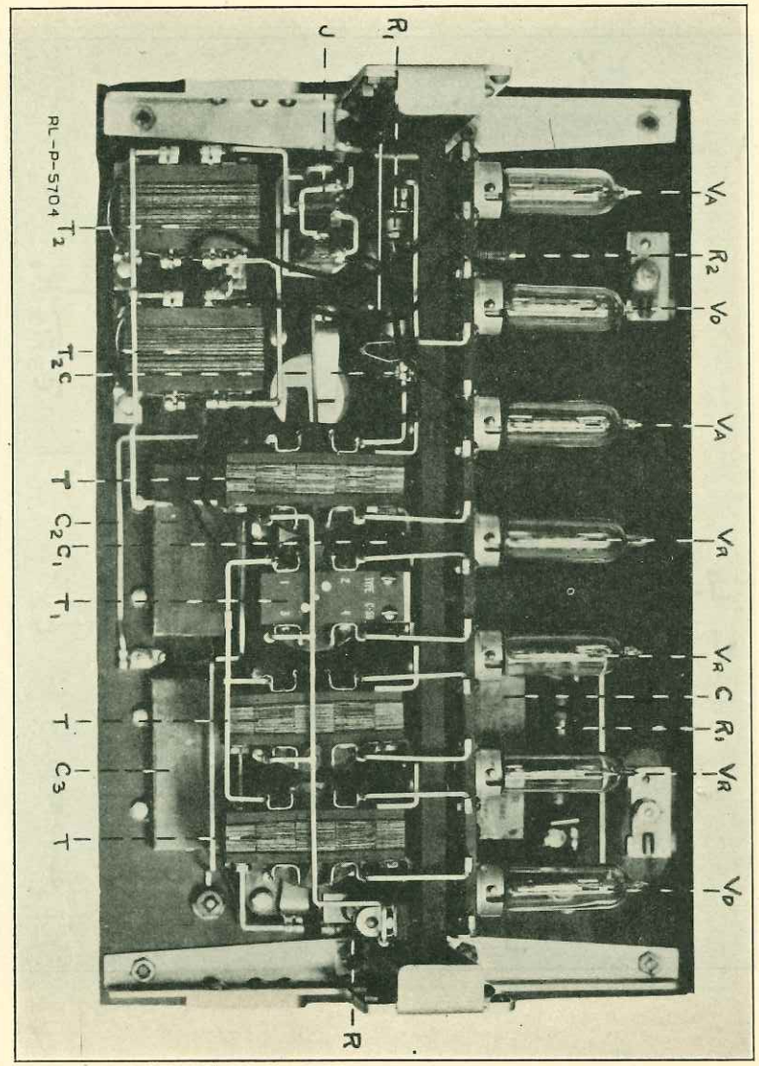


FIG. 49.—Inside view of amplifier, BC 116

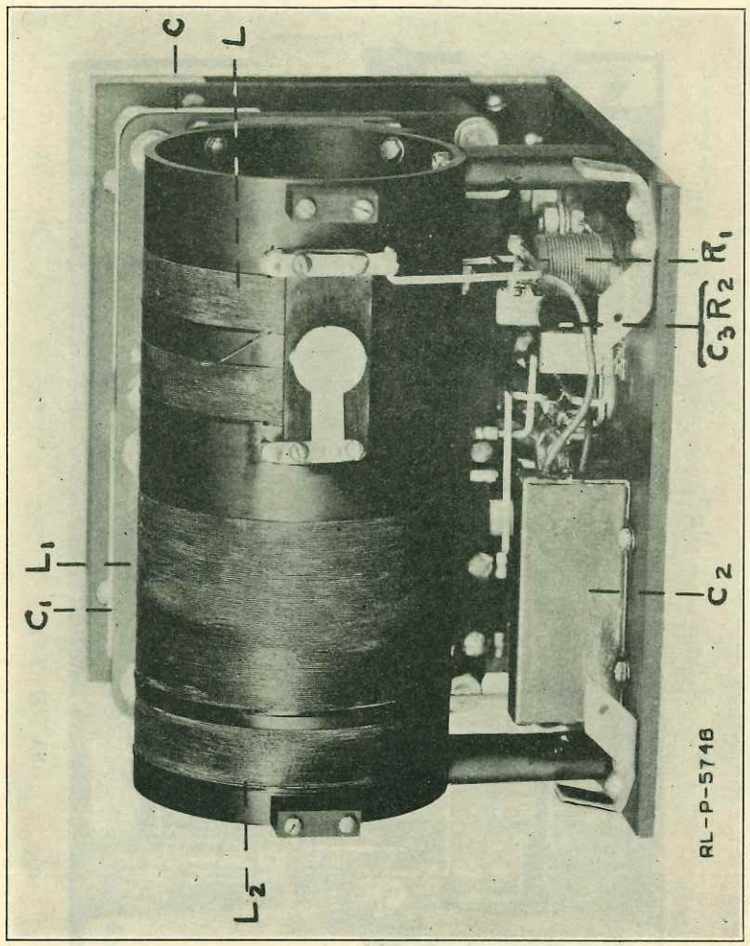


FIG. 50.—Tuner, BC 115. Rear inside view

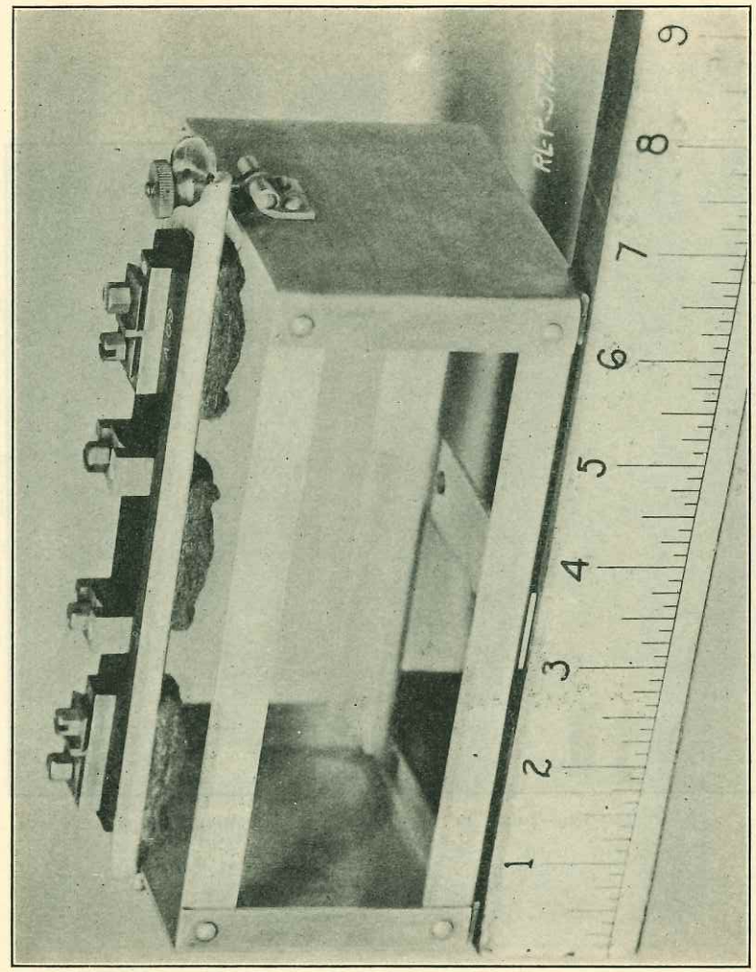


FIG. 51.—Box, battery, type BC 128

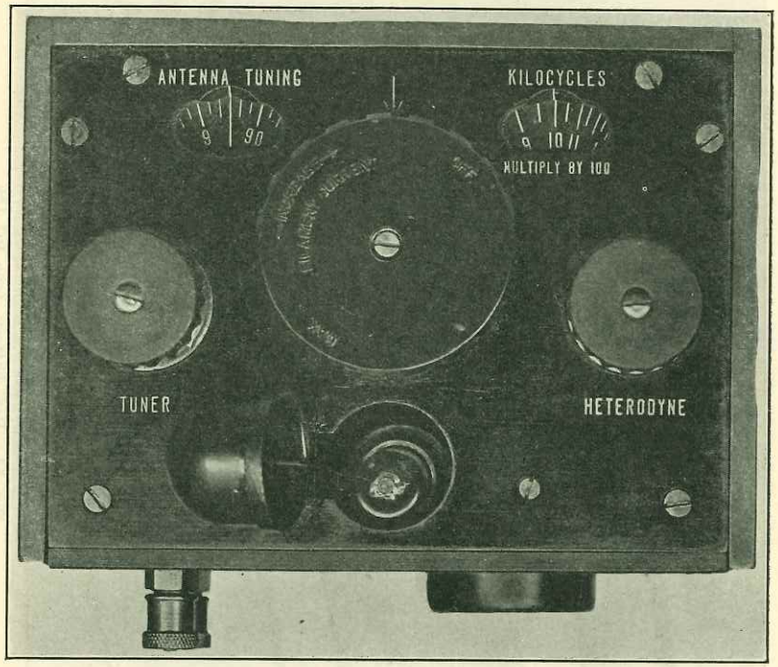


FIG. 52.—Tuner, BC 115. Front view, showing tube

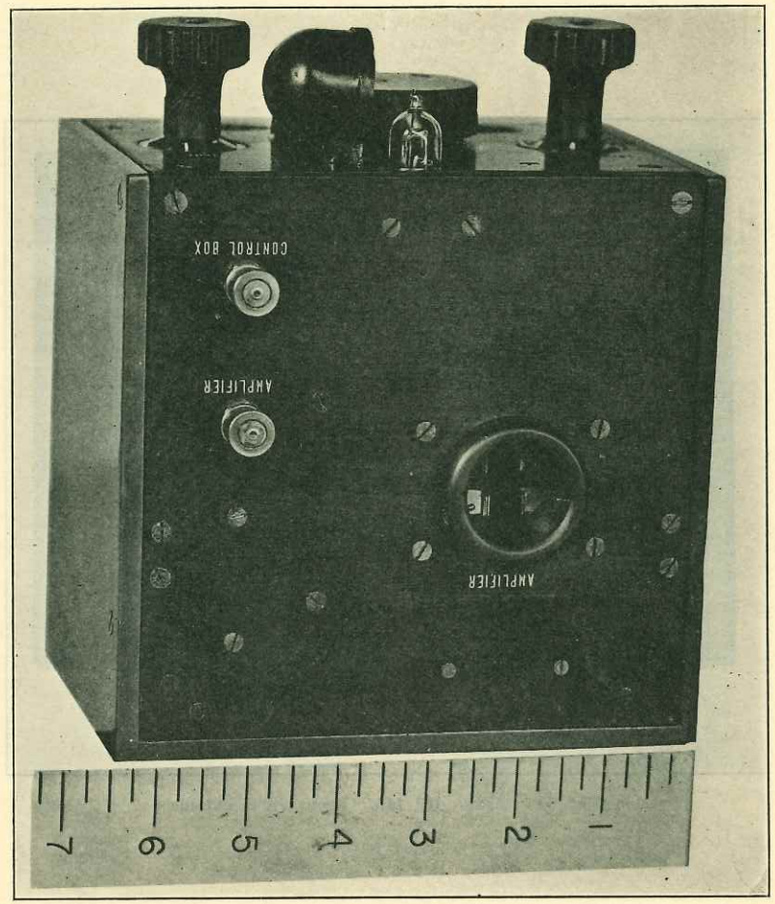


FIG. 53.—Tuner, BC 115. Bottom view

44027—25——7

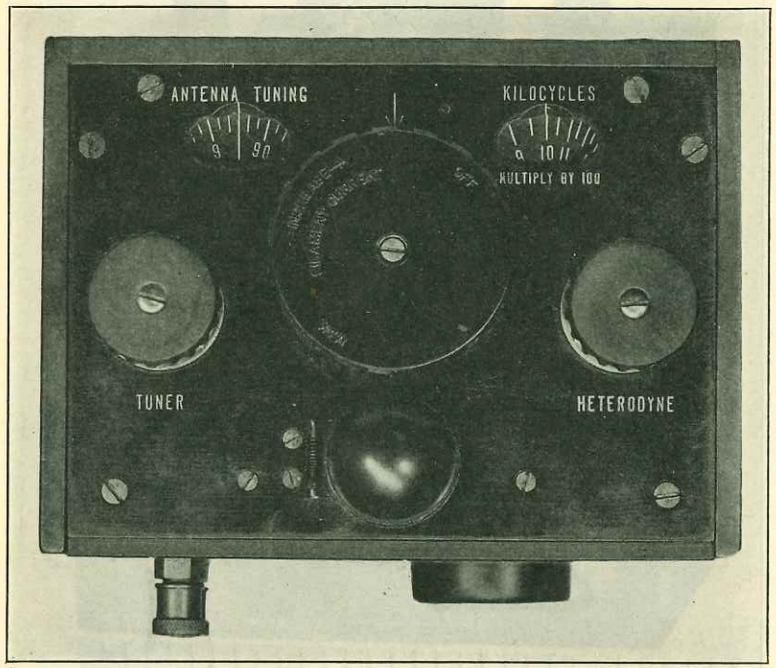


FIG. 54.—Tuner, BC 115. Front view, outside